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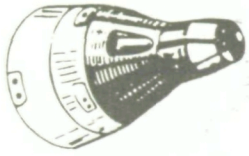

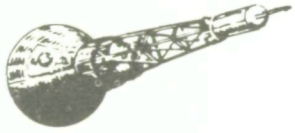

MDC E0377

Phase B System Study
FINAL REPORT

DETAIL
MASS PROPERTIES REPORT

Part III (A)

BOOSTER DETAILS
HIGH VALUE

SPACE SHUTTLE

LOW COST

MCDONNELL DOUGLAS CORPORATION

MARTIN MARIETTA DENVER DIVISION

TRW SYSTEMS GROUP

PAN AM

(NASA-CR-143902) SPACE SHUTTLE PHASE B SYSTEM STUDY. PART 3(A): BOOSTER DETAILS. DETAIL MASS PROPERTIES REPORT Final Report (McDonnell-Douglas Corp.) 520 p

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Unclas

00/98 17886

REPORT MDC E0377
30 JUNE 1971

Space Shuttle System

PHASE B STUDY FINAL REPORT

Part III (A)
Booster Details

DETAIL MASS PROPERTIES REPORT

SUBMITTED UNDER

NASA CONTRACT NO. NAS 8-26016

DRD MA016M- DRL LINE ITEM 23

MCDONNELL DOUGLAS CORPORATION
MARTIN MARIETTA DENVER DIVISION
PAN AM
TRW SYSTEMS GROUP

VOLUME III

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1. INTRODUCTION PART III

Estimated burnout weight for the baseline Booster (Configuration 20B) is 746,059 pounds. Part III presents the analysis supporting this estimate. The baseline mission, for weight reporting, is an easterly launch with 65,000 pounds of payload. Accordingly, all weight substantiation is directed towards this mission. Weight differences between missions, however, are restricted to differences in cruise propellant. Hardware weights are therefore applicable to all missions. Weight summaries for all three missions are presented in Table 1-1.

A general arrangement drawing of the analyzed vheicle is shown in Figure 1-1. Ascent propellants are liquid hydrogen and oxygen, loaded at a mixture ratio of 6. Maximum Booster propellant capacity (usable) is 3,084,000 pounds. Ascent propulsion is provided by (12) - 550K (S.L. thrust) liquid propellant rocket engines. Engine characteristics and mass properties are per ICD 13M15000B. Cruiseback propulsion is provided by (10) - GE F101/12B-3 turbojet engines, using JP-4 as a propellant. 131,000 pounds of JP-4 (usable) is required for the baseline mission (easterly launch). However, cruise propellant tanks, located in the wings and intertank area, have been oversized to permit using JP-4 for CG management.

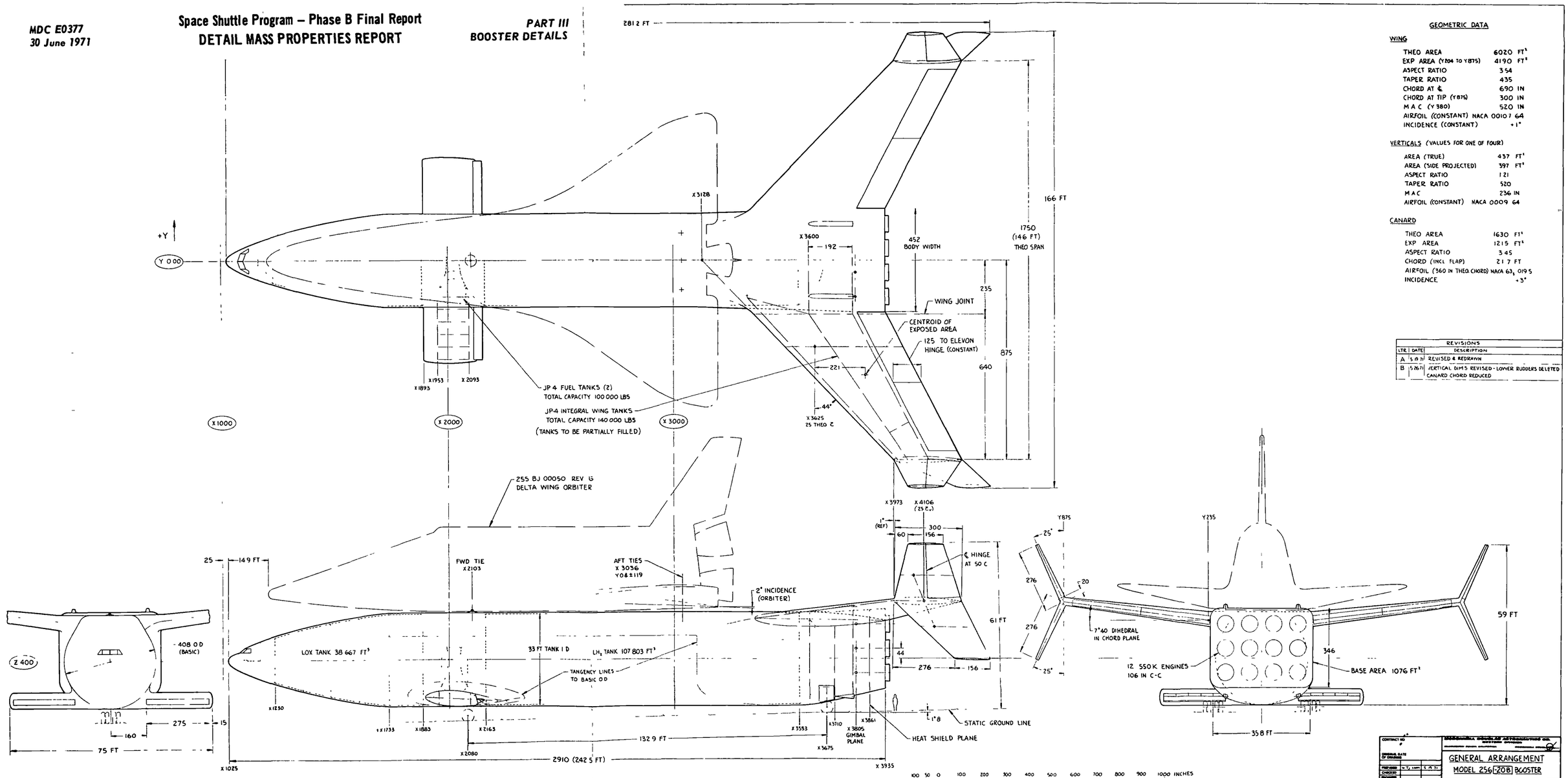
Weight substantiation for the Booster is primarily in the form of detailed weight calculations, supplemented by contingencies or non-optimum factors. Weights for system elements unsuitable to this approach (e.g., valves, motors, etc.) have been obtained from vendor estimates and/or correlations with existing hardware. In this volume an attempt has been made to avoid purely impirical methods. Impirical correlations, however, provide corroboration for estimates obtained by other techniques. Subsystem weights derived in this volume have therefore been compared with impirical trend data. These correlations with existing hardware are presented in Part I.

Table 1-2 quantifies the maturity of the Booster weight estimate by giving percentages of estimated and calculated weights. For this evaluation, liberties have been taken with the generally accepted definition of estimated and calculated. Calculated has been interpreted to cover all estimating methods exclusive of impirical techniques. This would include all calculations based on layouts, sketches, etc., plus any vendor furnished weights. It should be kept in mind, however, that in the generally accepted connotation all weights presented herein are estimated.

Table 1-1

WEIGHT SUMMARY (LAUNCH CONDITION)

	BY	DATE	
SYSTEM	EASTERLY	RESUPPLY	POLAR
WING GROUP	57,954	57,954	57,954
TAIL GROUP	19,214	19,214	19,214
BODY GROUP	148,599	148,599	148,599
INDUCED ENVIR PROTECTION	84,807	84,807	84,807
LANDING, RECOVERY, DOCKING	25,885	25,885	25,885
PROPULSION–ASCENT	123,320	123,320	123,320
PROPULSION–CRUISE	37,053	37,053	37,053
PROPULSION–AUXILIARY	5,396	5,396	5,396
PRIME POWER	3,582	3,582	3,582
ELECT CONVER & DISTR	1,818	1,818	1,818
HYDRA CONVER & DISTR	7,282	7,282	7,282
SURFACE CONTROLS	11,320	11,320	11,320
AVIONICS	4,941	4,941	4,941
ENVIRONMENTAL CONTROL	2,058	2,058	2,058
PERSONNEL PROVISIONS	288	288	288
RANGE SAFETY & ABORT			
BALLAST			
GROWTH/UNCERTAINTY	42,009	45,054	42,483
SUBTOTAL (DRY WEIGHT)	(575,526)	(578,571)	(576,000)
PERSONNEL	522	522	522
CARGO			
ORDNANCE			
RESIDUAL FLUIDS	14,707	14,567	14,127
SUBTOTAL (INERT WEIGHT)	(590,755)	(593,660)	(590,649)
RESERVE FLUIDS	34,245	27,245	11,245
IN FLIGHT LOSSES	22,847	22,847	22,847
PROPELLANT–ASCENT	3,038,600	3,038,600	3,038,600
PROPELLANT–CRUISE	97,000	97,000	91,000
PROPELLANT–MANEUV ACS	1,212	1,212	1,212
TOTAL (GROSS-WEIGHT) LB	(3,784,659)	(3,780,564)	(3,755,553)



GEOMETRIC DATA

WING

THEO AREA	6020 FT²
EXP AREA (Y204 TO Y875)	4190 FT²
ASPECT RATIO	354
TAPER RATIO	435
CHORD AT ℄	690 IN
CHORD AT TIP (Y875)	300 IN
M A C (Y 380)	520 IN
AIRFOIL (CONSTANT)	NACA 00107 64
INCIDENCE (CONSTANT)	+1°

VERTICALS (VALUES FOR ONE OF FOUR)

AREA (TRUE)	437 FT²
AREA (SIDE PROJECTED)	397 FT²
ASPECT RATIO	121
TAPER RATIO	520
M A C	236 IN
AIRFOIL (CONSTANT)	NACA 0009 64

CANARD

THEO AREA	1630 FT²
EXP AREA	1215 FT²
ASPECT RATIO	345
CHORD (INCL FLAP)	217 FT
AIRFOIL (360 IN THEO CHORD)	NACA 63₁ 019 5
INCIDENCE	+3°

REVISIONS		
LTR	DATE	DESCRIPTION
A	5 9 71	REVISED & REDRAWN
B	5 26 71	VERTICAL DIMS REVISED - LOWER RUDDERS DELETED CANARD CHORD REDUCED

CONTRACT NO
#
ORIGINAL DATE OF DRAWING
PREPARED
CHECKED
ENGINEER
DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL

GENERAL ARRANGEMENT
MODEL 256-208 BOOSTER

SIZE 18355 | CODE IDENT NO | DRAWING NO 256 20 0001 | REV B 5 26 71
SCALE 1/100 | SHEET 1 OF 1

Table 1-2

WEIGHT SUMMARY (LAUNCH CONDITION)					
CONFIGURATION					
CODE	SYSTEM	BOOSTER	EST	CAL	ACT
1	WING GROUP	57,954	9%	91%	
2	TAIL GROUP	19,214	12%	88%	
3	BODY GROUP	148,599	8%	92%	
4	INDUCED ENVIR PROTECTION	84,807	5%	95%	
5	LANDING, RECOVERY, DOCKING	25,885	42%	58%	
6	PROPULSION-ASCENT	123,320	16%	84%	
7	PROPULSION-CRUISE	37,053	6%	94%	
8	PROPULSION-AUXILIARY	5,396	8%	92%	
9	PRIME POWER	3,582	11%	89%	
10	ELECT CONVER & DISTR	1,818	12%	88%	
11	HYDRA CONVER & DISTR	7,282	77%	23%	
12	SURFACE CONTROLS	11,320	19%	81%	
13	AVIONICS	4,941	45%	55%	
14	ENVIRONMENTAL CONTROL	2,058	52%	48%	
15	PERSONNEL PROVISIONS	288	100%	0%	
16	RANGE SAFETY & ABORT				
17	BALLAST				
18	GROWTH/UNCERTAINTY	42,009	100%	0%	
19					
	SUBTOTAL (DRY WEIGHT)	(575,526)	19%	81%	
20	PERSONNEL	522	0%	100%	
21	CARGO				
22	ORDNANCE				
23	RESIDUAL FLUIDS	14,707	0%	100%	
24					
	SUBTOTAL (INERT WEIGHT)	(590,755)	19%	81%	
25	RESERVE FLUIDS	34,245	0%	100%	
26	IN FLIGHT LOSSES	22,847	0%	100%	
27	PROPELLANT-ASCENT	3,038,600	0%	100%	
28	PROPELLANT-CRUISE	97,000	0%	100%	
29	PROPELLANT-MANEUV/ACS	1,212	0%	100%	
30					
	TOTAL (GROSS-WEIGHT) LB	3,784,659	3%	97%	

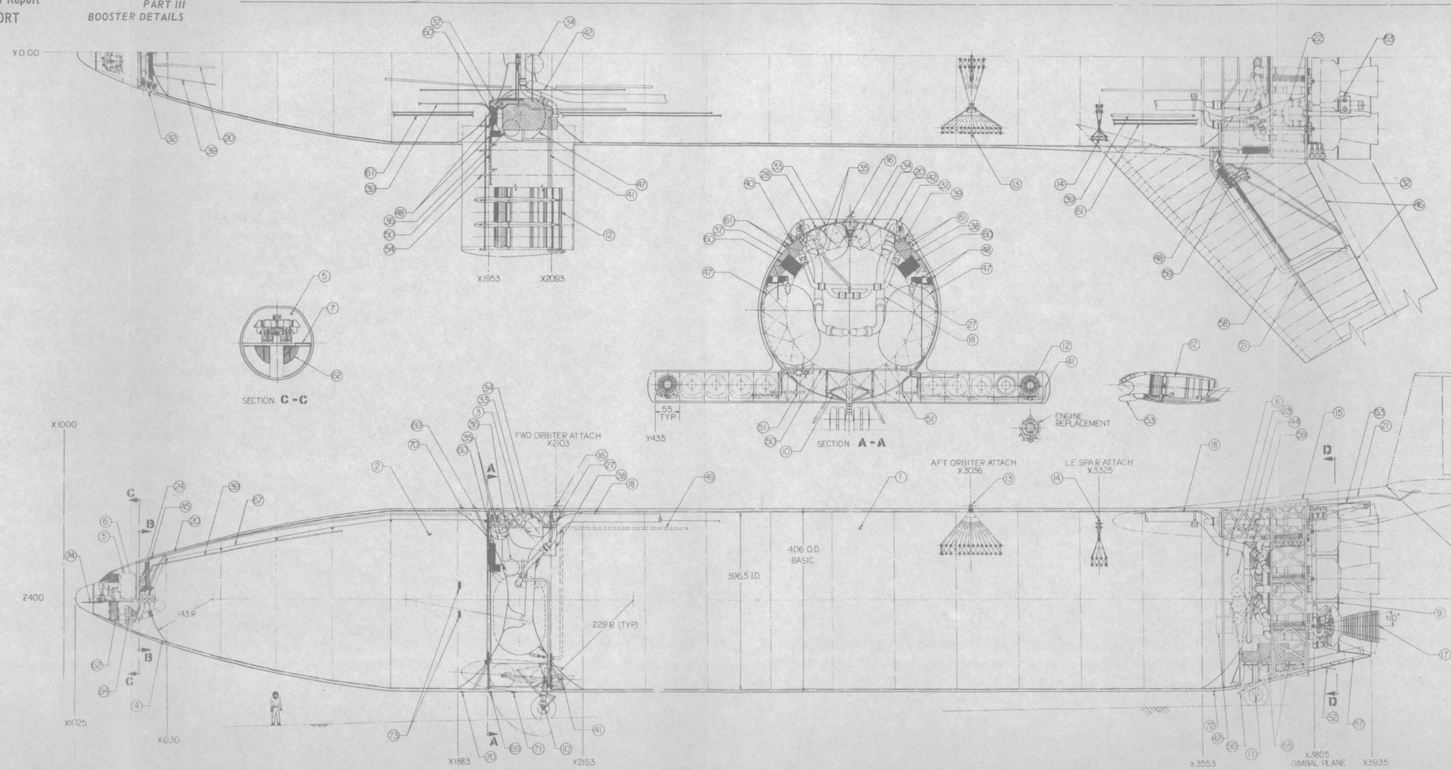
2.0 WEIGHT SUBSTANTIATION

Section 2.0 presents detailed weight substantiation for the baseline Booster. This portion of the report is divided into (29) subsections. These subsections correspond to the (29) functional codes of the group weight statement (Part I).

Each subsection is prefaced by a detailed weight summary of the functional group being considered. These summaries are identical to those presented in Part I, Appendix A. Following the detailed summary is a second summary in the same format as the group weight statement. The remainder of each section is devoted to weight substantiation.

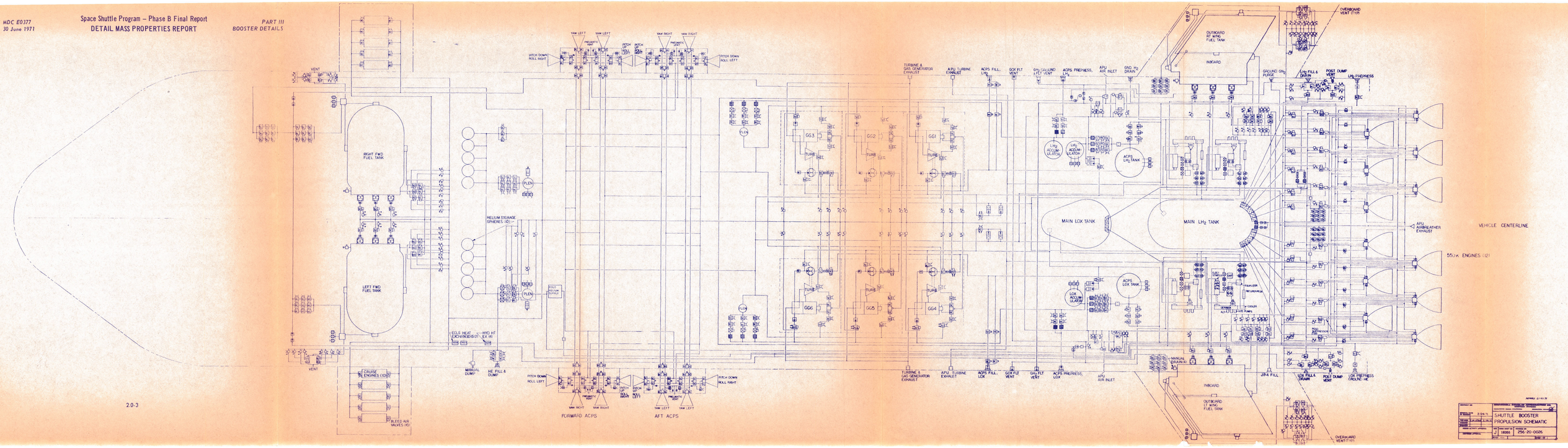
To assure traceability, all information used in the derivation of system weights has been either included or referenced. To add clarity, design drawings and schematics appropriate to each system have also been included.

Drawings appropriate to the derivation, but covering more than one system have been included in this section (2.).



1. LH_2 TANK ASSY
2. LO_2 TANK ASSY
3. INTERTANK STRUCTURE
4. NOSE SECTION
5. CREW CABIN
6. CABIN ACCESS DOOR
7. ACCESS HATCH TO EQUIP. BAY
8. AFT STUCTURE ASSY
9. BASE HEAT SHIELD
10. NOSE LANDING GEAR
11. MAIN LANDING GEAR
12. AIR BREATHING ENGINE INSTALL. (10)
13. AFT ORBITER ATTACH STRUCTURE
14. WING LEADING EDGE ATTACH STUCT.
15. LAUNCH PAD HOLD DOWN (4)
16. FWD ORBITER ATTACH STRUCT.
17. MAIN PROPULSION ENGINE (12)
18. LO_2 FEED MANIFOLD (2)
19. LO_2 ISOLATION VALVE (2)
20. LO_2 PRESSURIZATION LINE
21. LO_2 WING VENT
22. LO_2 FILL, DRAIN & DUMP
23. LO_2 RECIRCULATION SYST.
24. LO_2 GROUND VENT
25. LH_2 FEED DUCT (12)
26. LH_2 ISOLATION VALVE (12)
27. LH_2 FLIGHT VENT
28. LH_2 PRESSURIZATION LINE
29. LH_2 WING VENT
30. LH_2 FILL, DRAIN & DUMP
31. LH_2 RECIRCULATION SYST.
32. A.C.P.S. THUSTER
33. LH_2 STORAGE
34. LO_2 STORAGE
35. GH_2 ACCUMULATOR
36. GO_2 ACCUMULATOR
37. H_2 CONDITIONING SYST.
38. O_2 CONDITIONING SYST.
39. GO_2 MANIFOLD
40. GH_2 MANIFOLD
41. A.C.P.S. TURBINE EXHAUST
42. HELIUM MANIFOLD
43. PNEUMATIC CONTROL MODULE
44. HELIUM STORAGE SPHERE (10)
45. H_2 VENT MANIFOLD
46. JP FUEL TANK (WING)
47. JP FUEL TANK (FWD)
48. JP PRESSURE & VENT VALVE GROUP
49. JP TRANSFER LINE
50. JP FUEL MANIFOLD
51. ENGINE BLEED AIR MANIFOLD
52. JP FILL, DRAIN & INFLIGHT DUMP
53. ABES INLET DOOR
54. ABES INLET DOOR ACTUATOR
55. DUAL MODE APU
56. APU PLENUM INLET DOOR
57. JP TURBINE EXHAUST
58. H_2O_2 TURISINE EXHAUST
59. MAIN POWER CONTROL UNIT - ELEC. (4)
60. MIDSHIP POWER CONTROL UNIT - ELEC.
61. ELECTRICAL POWER DIST. LINE
62. FWD POWER CONTROL UNIT - ELEC. (4)
63. POWER UMBILICAL - ELEC. (4)
64. E.C.L.S. INSTALLATION
65. E.C.L.S. FREON & AIR LINES
66. CONTROL CABLE ROUTING
67. NOSE & MAIN GEAR TIMER RELEASE
68. GLIDE SLOPE ANTENNA (6)
69. DME ANTENNA
70. UHF ANTENNA (2)
71. ATC TRANSP. ANTENNA (1)
72. RADAR ALTIMETER ANTENNA (6)
73. VOR/LOC ANTENNA (2)
74. AIR DATA PROBE

INBOARD PROFILE
MODEL 256-1-208
BOOSTER



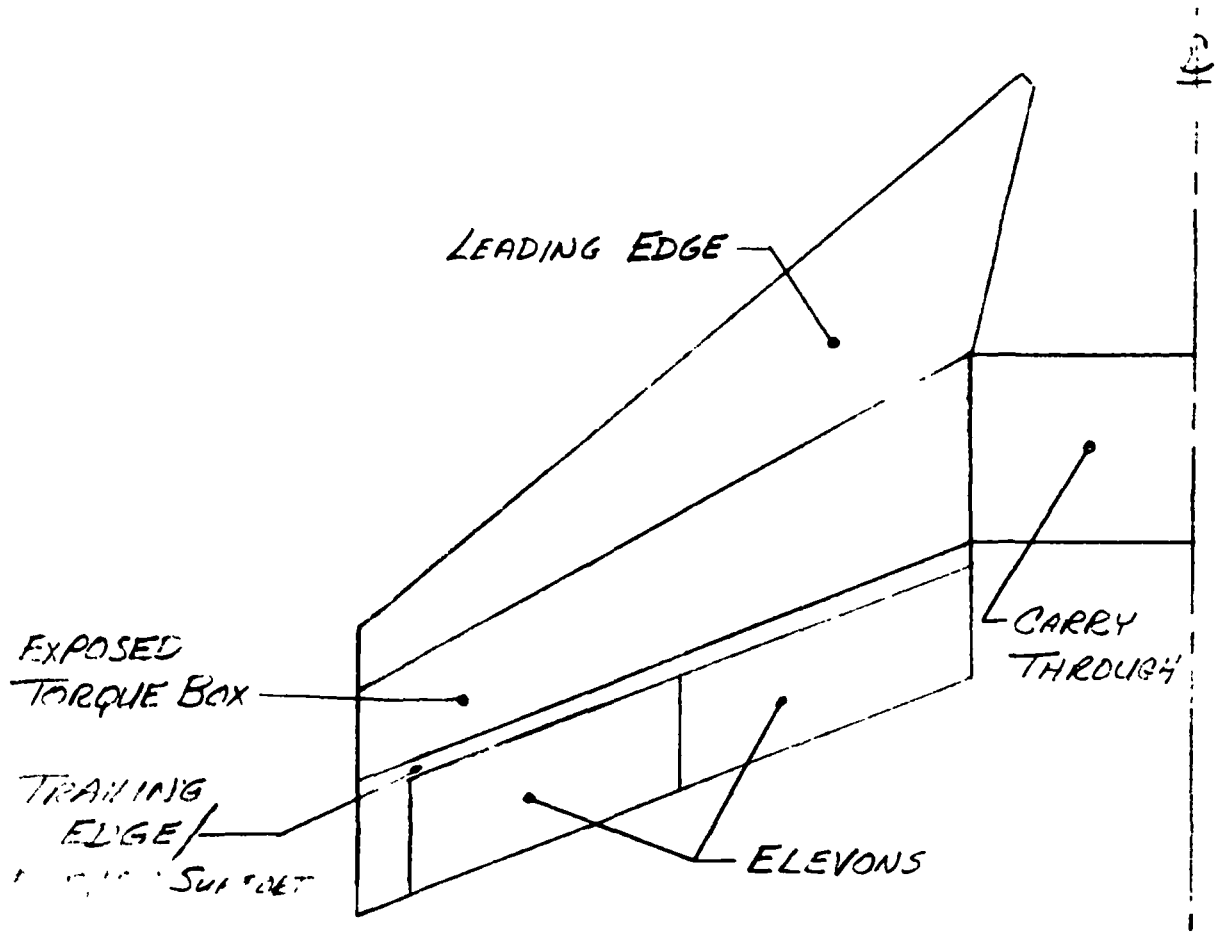
	SHUTTLE BOOSTER PROPULSION SCHEMATIC	
	J 18355	256-20-0026

1. WING GROUP

57954

		WEIGHT (LB)	PAGE NO.
CARRY THROUGH		[15414]	2.1-16
TORQUE BOX		(15414)	
COVERS - UPPER		6400	
- LOWER		5450	
FRONT SPAR		792	
AFT SPAR		298	
RIBS		1740	
ATTACH, SPLICES, JOINTS		734	
	1/2 WING	FULL WING	
EXPOSED WING	[21270]	[42540]	
LEADING EDGE	(4700)	(9400)	2.1-24
NOSE	1135	2270	
COVERS	1914	3828	
SPAR	377	754	
RIBS	278	556	
FORMERS	644	1288	
ATTACH, SPLICE, JOINTS	352	704	
TORQUE BOX	(13410)	(26820)	2.1-56
COVERS			
SKIN	4654	9308	
STRINGERS	4253	8506	
FRONT SPAR	712	1424	
AFT SPAR	717	1434	
RIBS	1157	2314	
FORMERS	966	1932	
WING-BODY ATTACH	160	320	
FITTINGS	54	108	
ATTACH, SPLICE, JOINT	737	1474	

	WEIGHT (LB)		PAGE NO.
	1/2 WING	FULL WING	
TRAILING EDGE	(445)	(890)	2.1-129
GAP COVER	148	296	
OUTB'D PANEL	97	194	
HINGE FTGS	160	320	
ATTACH, SPLICES	40	80	
INBOARD ELEVON	(1374)	(2748)	2.1-133
COVERS	452	904	
RIBS	168	336	
SPARS	258	516	
FORMERS	92	184	
END PANELS	48	96	
FITTINGS	127	254	
AEROSEAL	50	100	
ATTACH, JOINTS	179	358	
OUTBOARD ELEVON	(1341)	(2682)	2.1-147
COVERS	440	880	
RIBS	170	340	
SPARS	265	530	
FORMERS	92	184	
END PANELS	48	96	
FITTINGS	128	256	
AEROSEAL	46	92	
ATTACH, JOINT, SPLICES	181	362	



1. WING GROUP	CARRY THROUGH	EXPOSED SURFACE	51634	57254
BASIC STRUCTURE	(15414)	(36220)		
TORQUE BOX	15414	26820		
LEADING EDGE		9400		
TRAILING EDGE				
SECONDARY STRUCTURE				
VARIABLE GEOMETRY (INCL ____ LBS MECHANISM)				
DOORS, INSULATION, FAIRINGS				
CONTROL SURFACES	SURFACE	SUPT/MECH	6320	
ELEVONS	5430	890		
T.E. FLAPS				
L.E. FLAPS				
SPOILERS				
SPEED BRAKES				

WING

DETAILED WEIGHT SUBSTANTIATION

WING WEIGHT SUBSTANTIATION IS PRESENTED ON THE FOLLOWING PAGES. WEIGHTS FOR PRIMARY STRUCTURE, REFLECT CALCULATIONS FROM DESIGN LAYOUTS. ALL SUCH WEIGHTS ARE SUPPORTED BY LOADS AND STRESS ANALYSIS WEIGHT ALLOWANCES FOR JOINTS, SPLICES AND FASTENERS ARE BASED ON CORRELATIOUS WITH SIMILAR HARDWARE. TO PROVIDE TRACEABILITY, LOADS AND MATERIAL SUMMARIES USED IN THE WEIGHT DERIVATION HAVE BEEN INCLUDED. A COMPLETE LOADS AND STRUCTURAL ANALYSIS IS PRESENTED IN MDAC MEMO SSP1-E450-576.

ALL STRUCTURE IS OF AL 7075-T73 MATERIAL WHICH HAS A DENSITY OF .101 LB/IN^3. WEIGHT TABLE COMPARISONS ARE INCLUDED IN THE FOLLOWING PAGES WHICH OFFER ADDITIONAL SUBSTANTIATION. THE FOLLOWING LIST OF DRAWINGS IS GIVEN AS AN AID TO THE REFERENCING OF THE WEIGHT CALCULATIONS WHICH FOLLOW.

Drawing No.	Items under Consideration
899A2010599 - 1 OF 8	All areas, Dimension.
2 OF 8	Torque Box Covers, Leading Edge Covers, Closing Rib
3 OF 8	Cover Wing-Body Attach, Cover Stringers, Cover Splices, Forward Member of Closing Rib, Front Spar
4 OF 8	Elevons, Trailing Edge, Torque Box Bulkheads, Leading Edge Rib, Leading Edge
5 OF 8	Trailing Edge Gap Cover Hinge Fittings

WING

DETAILED WEIGHT SUBSTANTIATION (CONT)

DRAWING No	
899A2010599-6 OF 8	TORQUE BOX REAR SPAR, TRUSS RIB, FORMER
7 OF 8	ELEVON FITTINGS, ELEVON, LEADING EDGE
8 OF 8	HINGE RIBS, FORMERS, LEADING EDGE RIBS

UNIT WEIGHT COMPARISONS

LEADING EDGE

$$\frac{2 \times 4700}{1497.5}^{*} = 6.28 \text{ PSF}$$

$$\frac{2 \times 3565}{1497.5} = 4.76 \text{ PSF}$$

* INCLUDE HOT STRUCTURE NOSE

VEHICLE	UNIT WEIGHT – PSF
SHUTTLE BOOSTER w/ HOT STRUCT.	6.28
" " w/o HOT STRUCT.	4.76
B-52	2.65
C-135	3.1
C-133	4.3
DC-9	4.3
DC-8	4.4
DC-10	4.6

TORQUE BOX

$$\frac{26820}{1271.6} = 21.09 \text{ PSF}$$

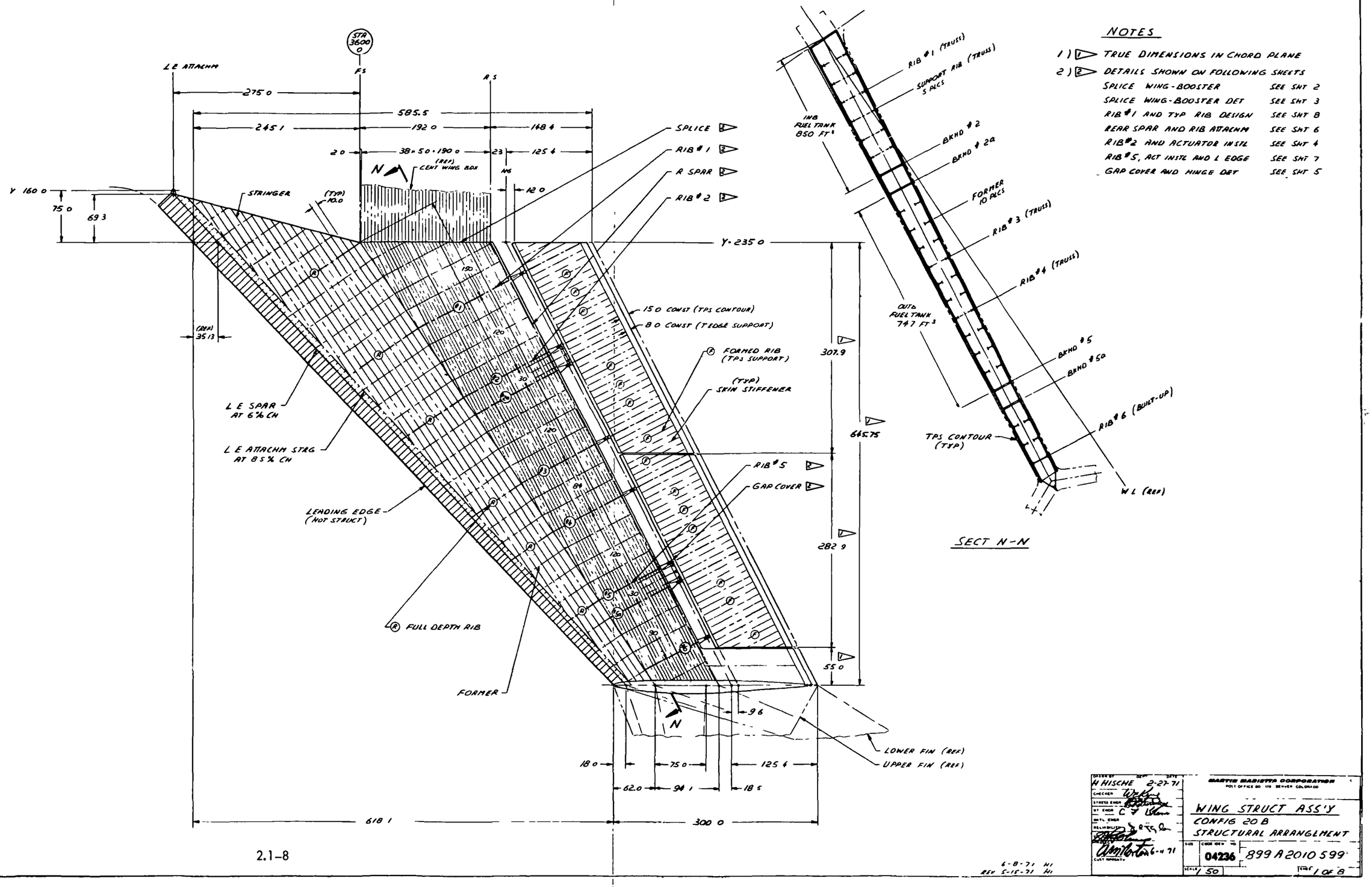
VEHICLE	UNIT WEIGHT – PSF
SHUTTLE BOOSTER	21.09
B-52	20.4
C 135	16.8
DC-9	15.4
DC-8	18.9
DC-10	19.0

UNIT WEIGHT COMPARISONS (CONT.)

ELEVONS

$$\frac{2748 + 2682}{966.9} = 5.62 \text{ PSF}$$

VEHICLE	UNIT WEIGHT-PSF
SHUTTLE BOOSTER	5.62
B-58	5.83
B-70	5.85



NOTES

1) 1 TRUE DIMENSIONS IN CHORD PLANE
2) 2 DETAILS SHOWN ON FOLLOWING SHEETS

SPLICE WING-BOOSTER	SEE SHT 2
SPLICE WING-BOOSTER DET	SEE SHT 3
RIB # 1 AND TYP RIB DESIGN	SEE SHT 8
REAR SPAR AND RIB ATTACHM	SEE SHT 6
RIB # 2 AND ACTUATOR INSTL	SEE SHT 4
RIB # 5, ACT INSTL AND L EDGE	SEE SHT 7
GAP COVER AND HINGE DET	SEE SHT 5

DRAWN BY H HISCHE	DATE 2-27-71
CHECKER	
STRESS ENGR	
WT ENGR	
MATL ENGR	
RELIABILITY	
CUST IMPRINTY	6-11-71

MARTIN MARIETTA CORPORATION
POST OFFICE BO 179 DENVER COLORADO

WING STRUCT ASS'Y
CONFIG 20 B
STRUCTURAL ARRANGEMENT

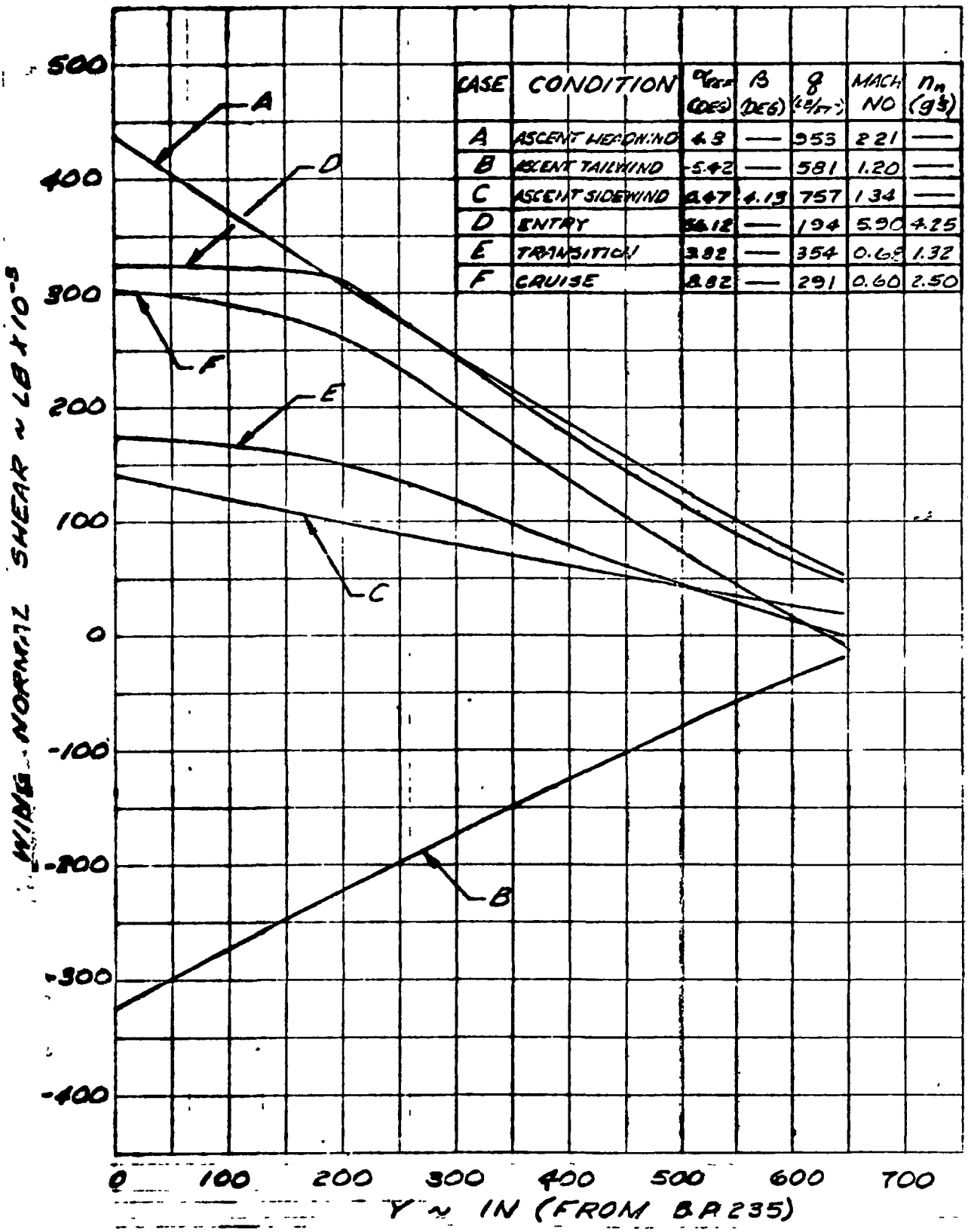
SIZE | CODE IDENT NO 04236 | 899 A 2010 599
SCALE 1/50 | SHEET 1 OF 8

6-8-71 HI
REV 5-15-71 HI

CONFIGURATION 20[illegible] BOOSTER WING

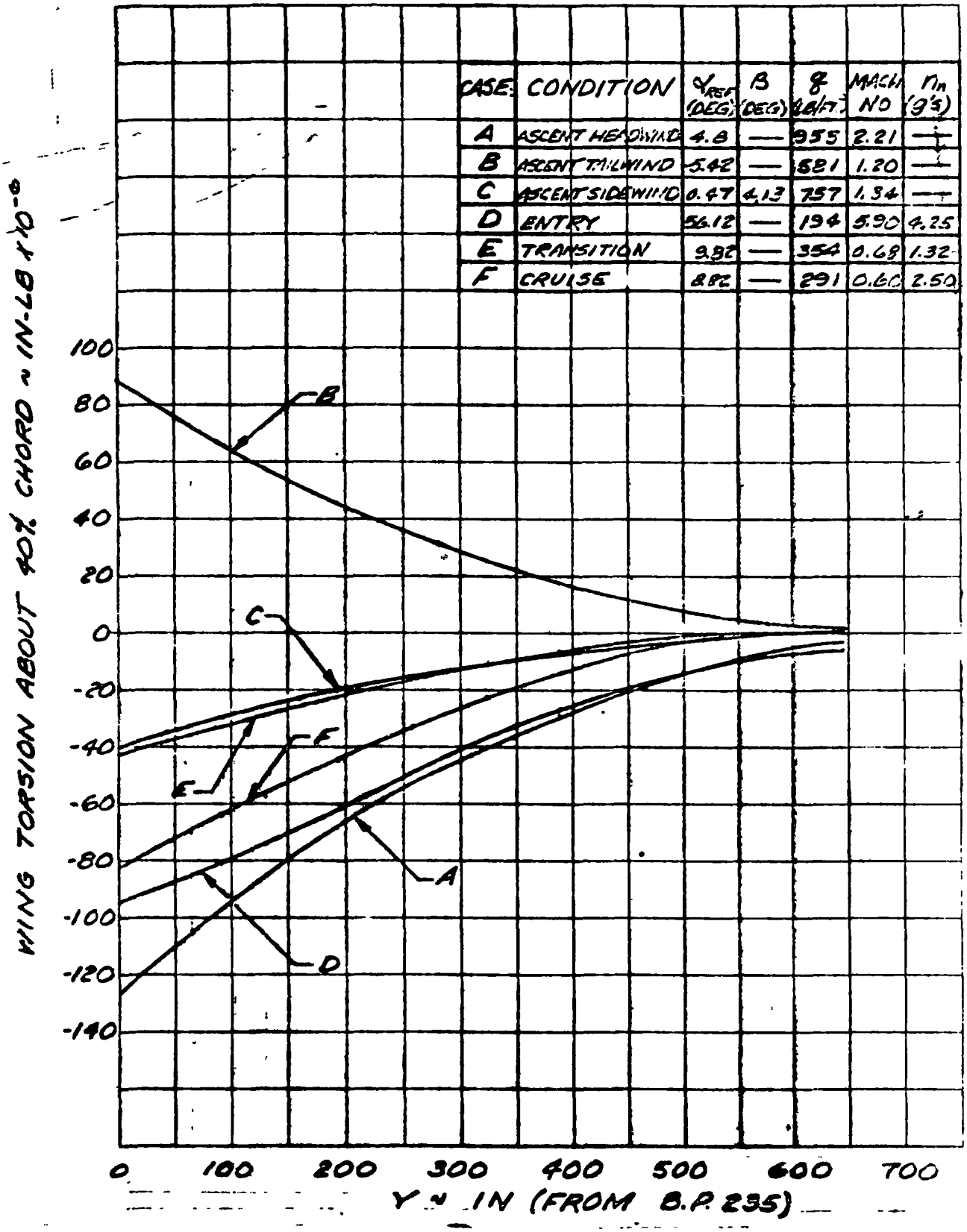
NORMAL SHEAR - RIGID LOADS

CASE	CONDITION	α_{REF} (DEG)	β (DEG)	q (LB/FT²)	MACH NO	n_n (g's)
A	ASCENT HEADWIND	4.3	—	953	2.21	—
B	ASCENT TAILWIND	-5.42	—	581	1.20	—
C	ASCENT SIDEWIND	2.47	4.13	757	1.34	—
D	ENTRY	36.12	—	194	5.90	4.25
E	TRANSITION	3.82	—	354	0.68	1.32
F	CRUISE	2.82	—	291	0.60	2.50



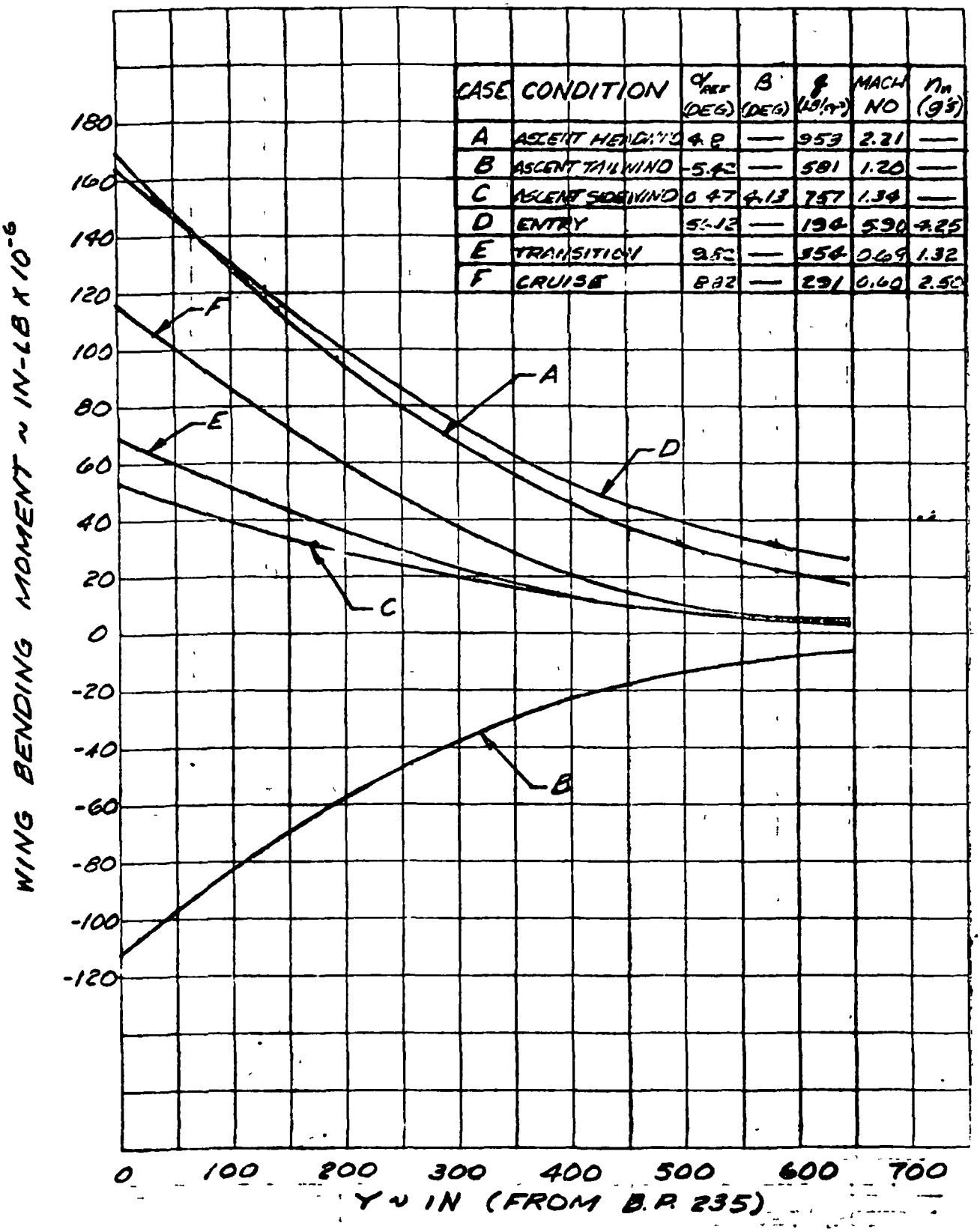
CONFIGURATION 20B BOOSTER WING.
TORSION - RIGID LOADS

CASE	CONDITION	γ_{REF} (DEG)	β (DEG)	q (LB/FT²)	MACH NO	n_m (g's)
A	ASCENT HEADWIND	4.8	—	955	2.21	—
B	ASCENT TAILWIND	5.42	—	521	1.20	—
C	ASCENT SIDEWIND	0.47	4.13	757	1.34	—
D	ENTRY	56.12	—	194	5.90	4.25
E	TRANSITION	9.92	—	354	0.68	1.32
F	CRUISE	8.82	—	291	0.60	2.50

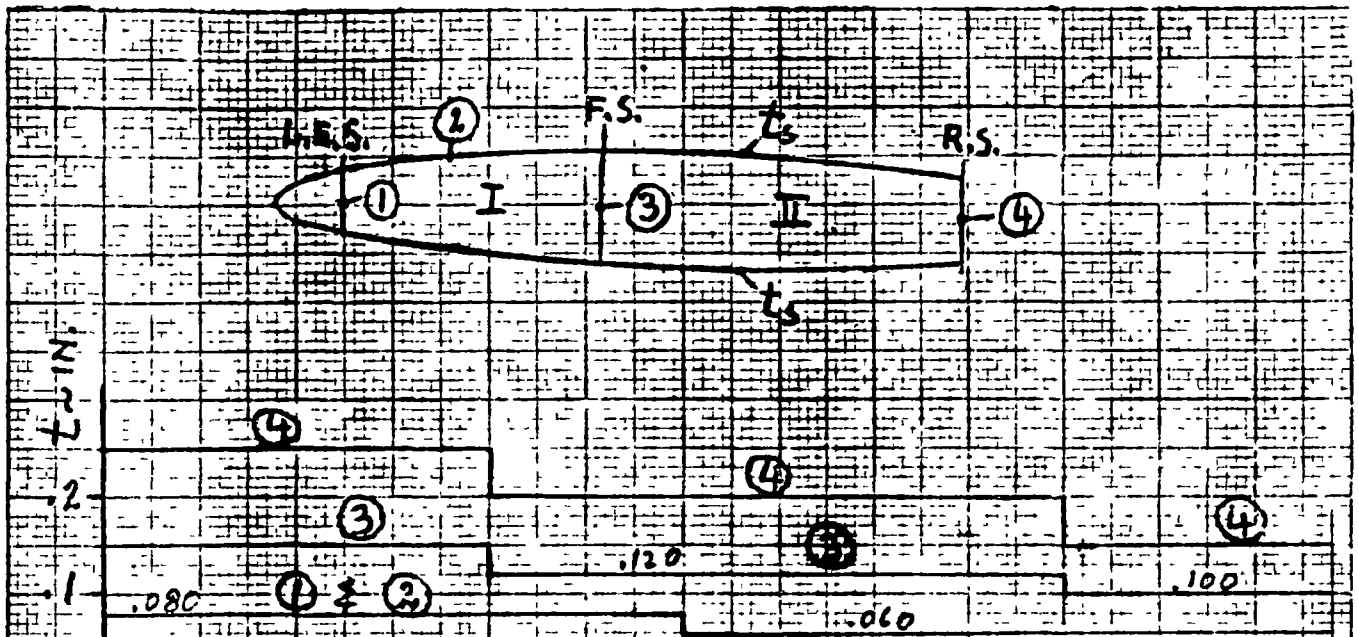


CONFIGURATION 208 BOOSTER WING.
BENDING MOMENT - RIGID LOADS

CASE	CONDITION	α_{REF} (DEG)	β (DEG)	q (LB/FT²)	MACH NO	n_m (g's)
A	ASCENT HEADWIND	4.8	—	953	2.21	—
B	ASCENT TAILWIND	-5.4	—	581	1.20	—
C	ASCENT SIDEWIND	0.47	4.13	757	1.34	—
D	ENTRY	5.12	—	194	5.90	4.25
E	TRANSITION	9.5	—	554	0.69	1.32
F	CRUISE	8.82	—	291	0.60	2.50



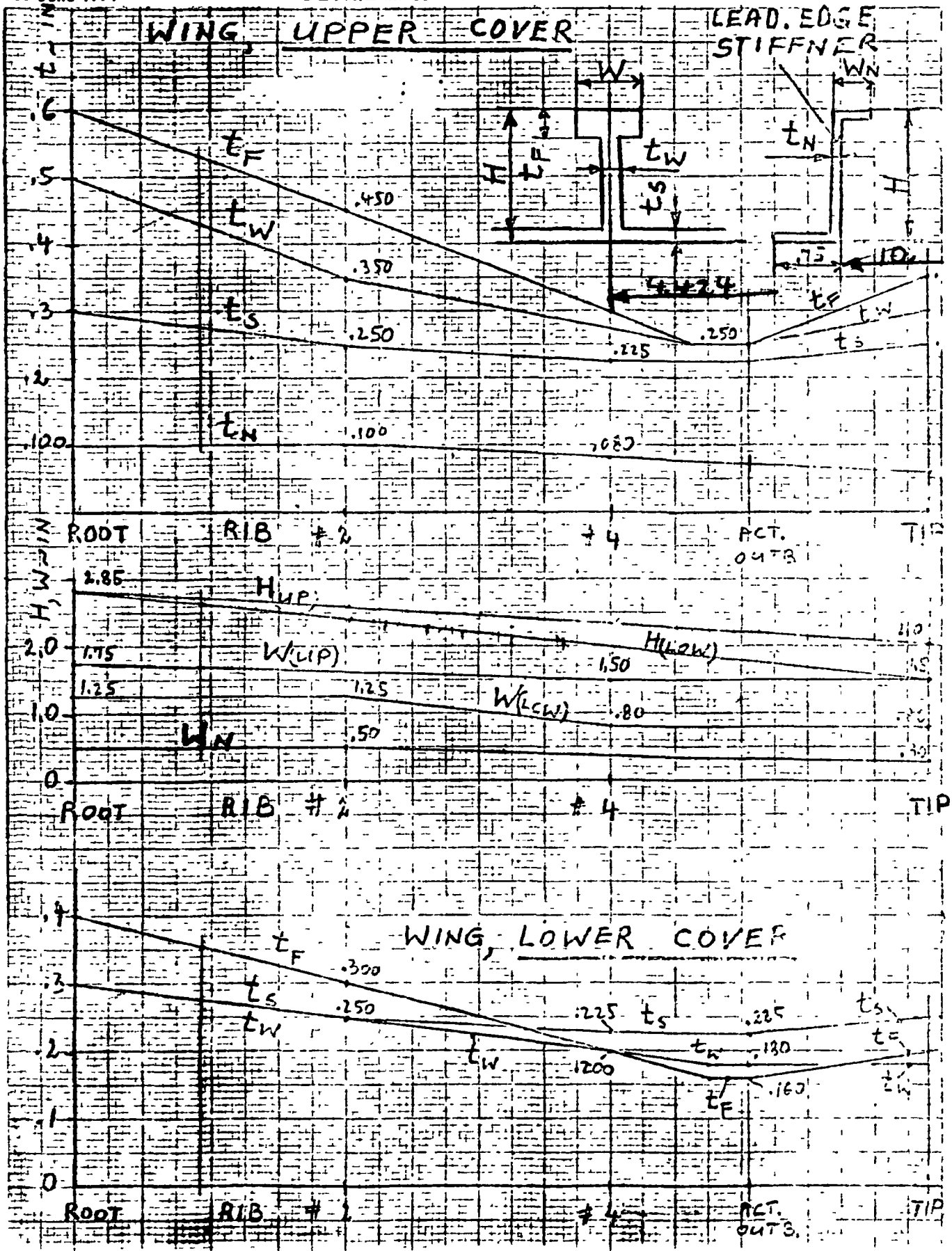
STRUCTURAL SIZES - WING



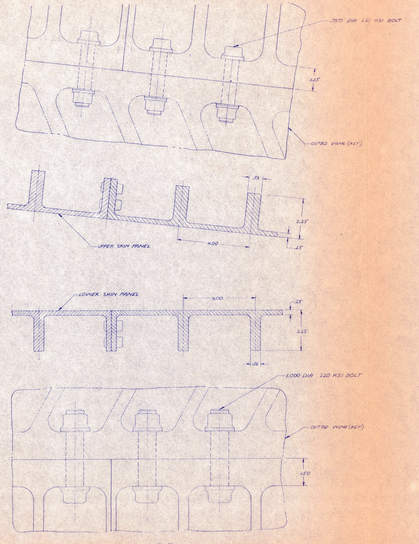
	L.E.S.	F.S.	CENT. SPAR	R.S.
	I			
ROOT	.080	.435 — .315	.230 — .365	

	I	II	R.S.
RIB 0	.070	—	
1	.050	.070	
2	.050	.090(2x)	
3	.040	.050	
4	.040	.050	
5	.050	.110(2x)	
6	—	.080	
TIP	.060	.090	

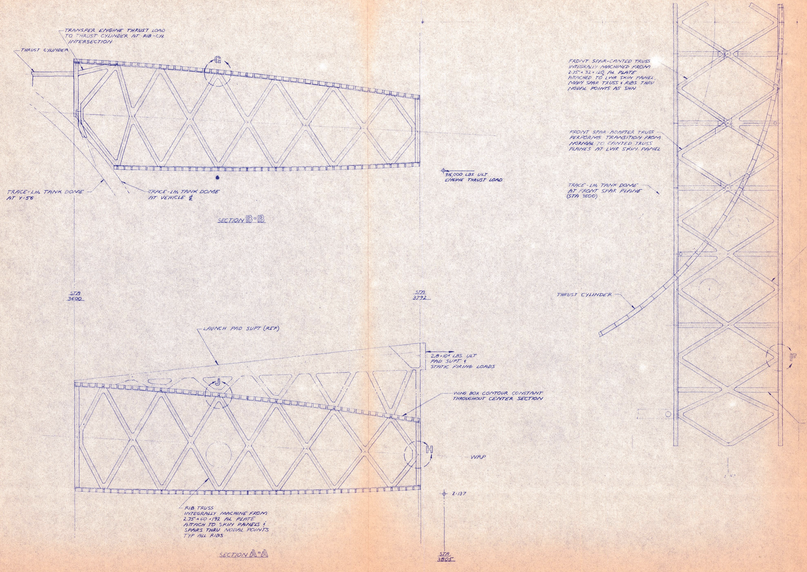
MAIN RIBS
THICKNESS ~ IN

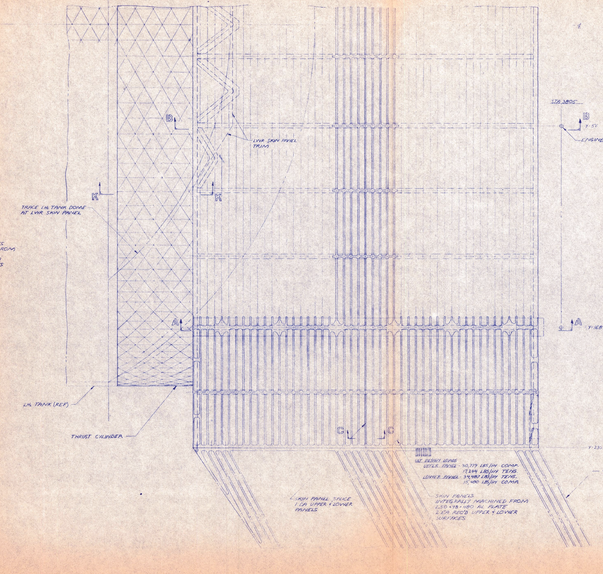

WING UPPER COVER
LEAD. EDGE STIFFNER
t_F
t_W
t_S
t_N
.450
.350
.250
.225
.100
.080
ROOT
RIB # 2
4
ACT. OUTB
TIP
2.85
1.75
1.25
H_{UP}
$W_{(UP)}$
$H_{(LOW)}$
$W_{(LOW)}$
1.50
.80
.50
W_N
WING LOWER COVER
.300
.250
.225
.200
.130
.160
RIB # 1

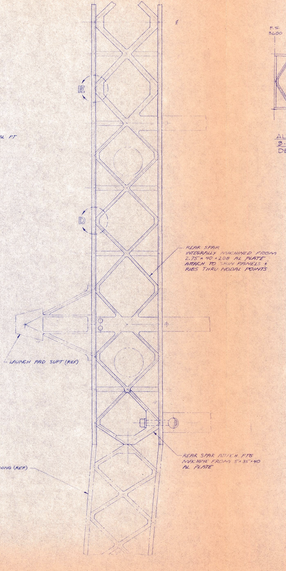
	WEIGHT (LB)
CARRY THROUGH SUMMARY	[15414]
TORQUE BOX	(15414)
COVERS - UPPER	6400
- LOWER	5450
FRONT SPAR	792
AFT SPAR	298
RIBS	1740
ATTACH, SPLICES, JOINTS	734



SECTION C-C
TYP SIM
FWD SKIRT SHOWN
AFT SKIRT SIMILAR







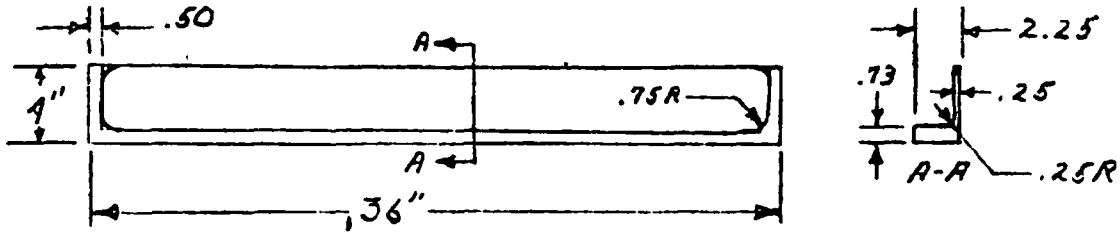
ALTERNATE GEOMETRY ARRANGEMENT FOR 2-BEARING BOX, REMAIN STRUCTURAL DETAILS APPLY

NOTE:
THE DESIGN CONCEPT ON THIS PAGE APPLIES TO GIMBAL BOX ONLY. ONLY MINOR CHANGES ARE REQ'D TO GIMBAL PITCH, YAW RING WITHDRAW ANGLES AND BEARING LOADING

			LH2 BODY STRUCTURE ASSEM
			CONFIG "D"
			4 BEARING BOX - 9.5FX120
			1555
			174-70-0002

UPPER SKIN PANEL - WING CARRY THRU

TYPICAL PANEL CROSS SECTION



AREA = 4 (36) = 144 IN²

VOLUME = $4(\overset{36}{36})(.25) + 8(\overset{8}{.50})(2) + 35(\overset{51.1}{2})(.73) + 9(\overset{.968}{2})(.121) + 76(\overset{.988}{.013}) = 97 IN^3$

$\bar{z}$ = 97.05/144 = 0.674 IN

PANEL AREA = L W = 193 (470) = 90700 IN²

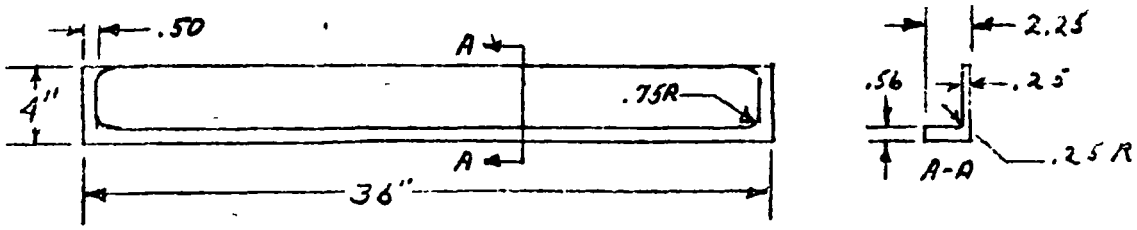
VOLUME OF NON-CONSTANT AREAS IS EQUAL TO INDIVIDUAL AREAS X (2.25 - $\bar{z}$)

$V = [3(\overset{579}{193}) + 26(\overset{134.5}{3})(1.75)](2.25 - \overset{1.583}{.667}) = 1132 IN^3$

PANEL WT = [90,700(.674) + 1132 + 115*](101) = 6900 LB

LOWER SKIN PANEL - WING CARRY THRU

TYPICAL PANEL CROSS SECTION



AREA = 4(36) = 144 IN²

VOLUME = $4(\overset{36}{36})(.25) + 8(\overset{8}{5})2 + 35(\overset{39.6}{2}).56 + 1(\overset{.968}{2})(.121) + 76(\overset{.988}{.013}) = 85.56 IN^3$

$\bar{z}$ = 85.56/144 = 0.594 IN

PANEL AREA = $192(\overset{90200}{470}) - 90(\overset{1980}{22})$ = 88320 IN²

VOLUME OF NON-CONSTANT AREAS IS EQUAL TO INDIVIDUAL AREAS X(2.25 - $\bar{z}$)

$V = [3(\overset{576}{192}) + 26(\overset{134.5}{3})(1.75)](2.25 - \overset{1.656}{.594}) = 1180 IN^3$

PANEL WT = [88320(.594) + 1180 + 378*](.101) 5450 LB

* VOLUME FOR ATTACH BEEF-UP CALCULATED ON PAGE 3

UPPER SKIN PANEL ATTACH BEEF-UP

BEEF-UP FOR ATTACHING AFT SPAR

$V = [3(6)\,3.25 + 12(2.5)(3.25)]\,1.583 - 18\,\pi/4\,(1.5)^2\,2.5 = 167\ IN^3$

BEEF-UP FOR ATTACHING FRONT SPAR

$V = [15(1.5)(3.25)]\,1.583 - 15\,\pi/4\,(.875)^2(2.5) =$ $94\ IN^3$

BEEF-UP FOR ATTACHING RIB TRUSSES

$V = 72[(\pi/4)(1.9)^2 - 1(1.8)]\,1.583$ $117\ IN^3$

BEEF-UP FOR ATTACHING LAUNCH PAD SUPPORT

$V = 19[3.3(7.25) + 5.5(2) + 1(3)]\,2 - 14(9.7)(.73)2$

$- 42(\pi/4)(1.25)^2(2.5) = 1006 - 96 - 129 =$ $781\ IN^3$

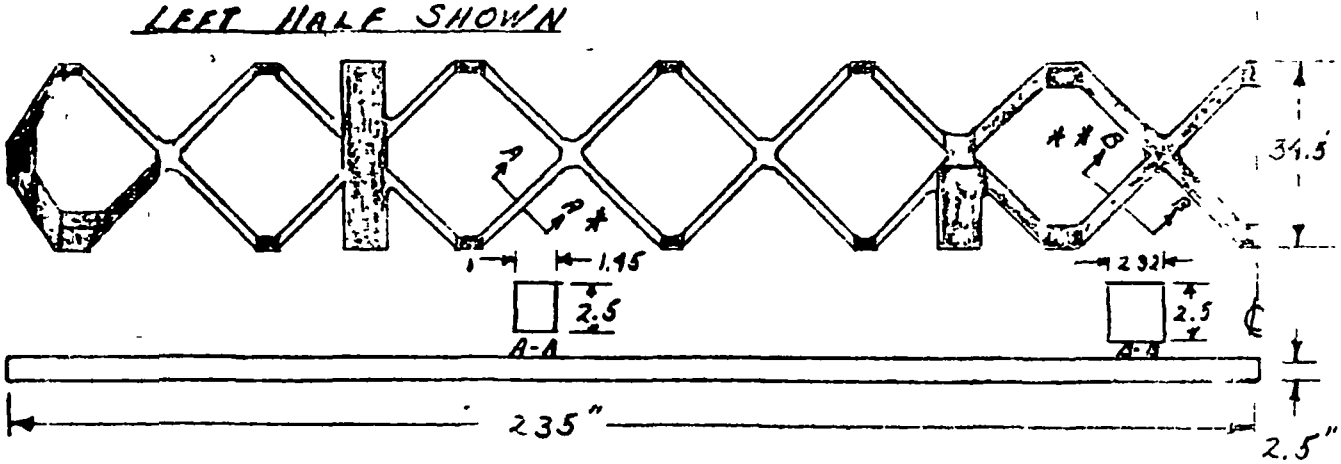
TOTAL $1159\ IN^3$

LOWER SKIN PANEL ATTACH BEEF-UP

BEEF-UP FOR ATTACHING AFT SPAR	$167\ IN^3$
BEEF-UP FOR ATTACHING FRONT SPAR	$94\ IN^3$
BEEF-UP FOR ATTACHING RIB TRUSSES	$117\ IN^3$
TOTAL	$378\ IN^3$

AFT SPAR - WING CARRY THRU

LEFT HALF SHOWN



VOLUME OF RED AREA

$$V=[2(3.5^{7})+9.5(2^{19})+5(13.5^{67.5})+8\,5(4^{34})+3(8.5^{25.5})+5.5(3.5^{19.3})+2(15^{30})$$
$$+8(4)(2^{64})+8(34.5^{276})+14.5(8^{114})+6(6^{36})+3(4.25^{12.8})6]2.5=$$
$$=707(2.5)=1768\ IN^3\ (1)$$

VOLUME OF BLUE AREA

$$V=[16+18.5+43^{117}+20+19.5]2.92(2.5)=\ 854\ IN^3$$

VOLUME OF WHITE AREA

$$V=[46+22+17+16+19+18.5+47+23+22+46+22+22.5$$
$$+20.5+17^{356.5}](1.45)2.5\ =\ 1300\ IN^3$$

TOTAL REAR SPAR WT $=2(3922)(.101)=$ 792 LB

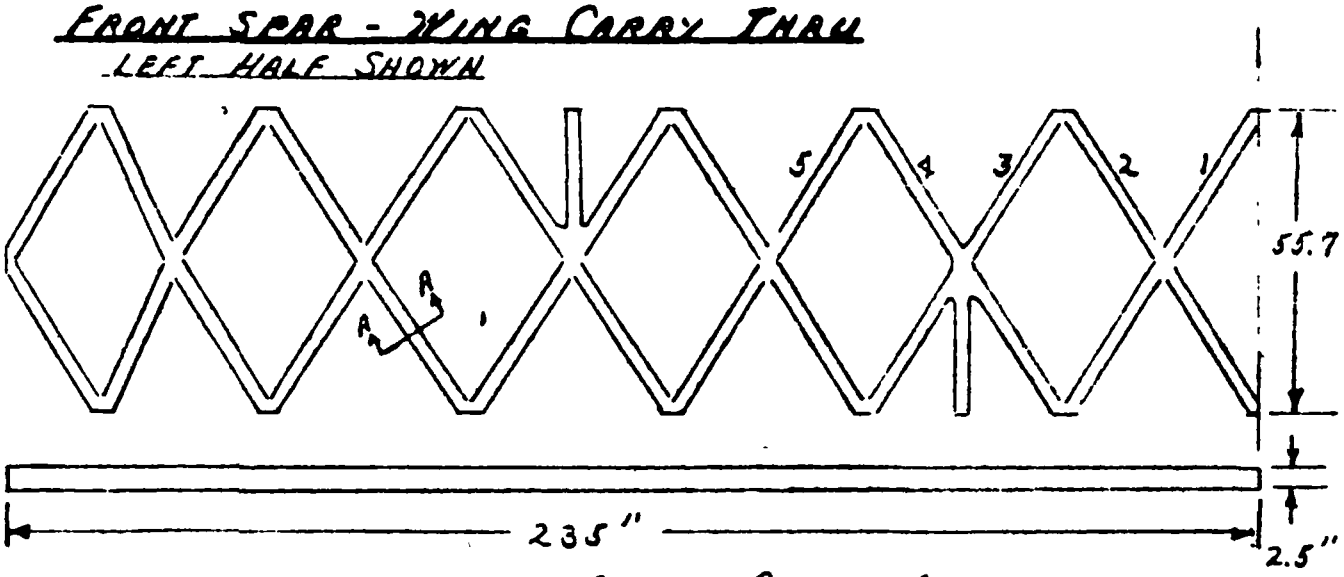
* LOAD ON SECTION A-A : 182,000 LBS ULT.

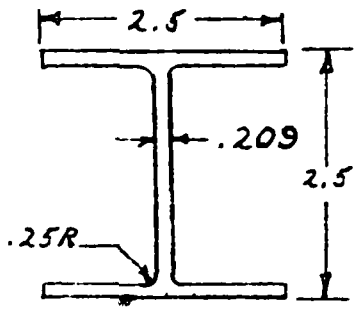
** LOAD ON SECTION B-B : 364,000 LBS ULT.

(1) INCLUDES ATTACH BEEF-UP

FRONT SPAR - WING CARRY THRU

LEFT HALF SHOWN





A - A

TYPICAL CROSS SECTION

AREA = [2(2.5) + 2.08] .209 + 9(.013) = 1.53 IN²

RIBS 1, 2, 3, 4, 5 ARE SLANTED TO CLEAR AFT LH_2 BLKHD

VOLUME OF RIBS:

$$V = [32 + 32 + 64 + 31 + 32 + 66.5 + 31.5 + 32 + 67 + 33 + 32 + 27 + 66 + 32 + 34 + 68 + 32 + 34 + 26 + 68 + 33 + 33] 1.53 = 906(1.53) = 1385 \text{ IN}^3$$

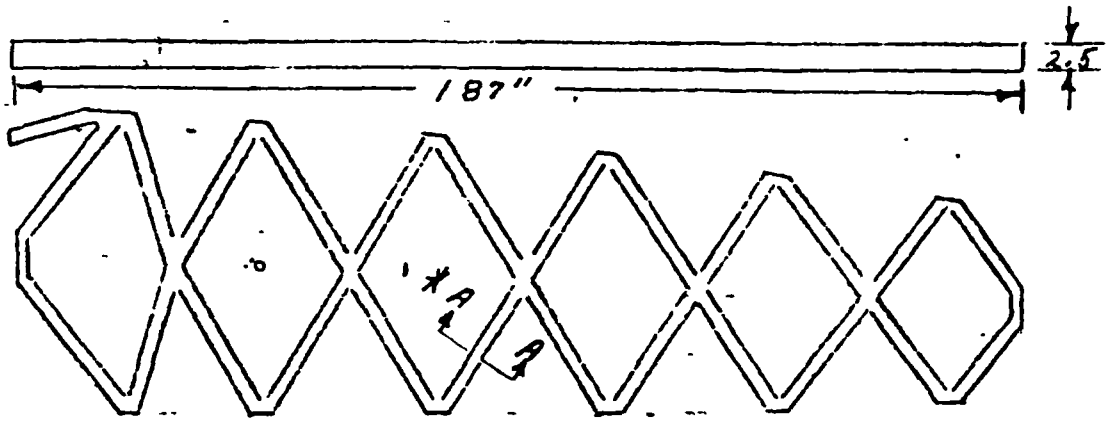
VOLUME OF ATTACH BEEF-UP:

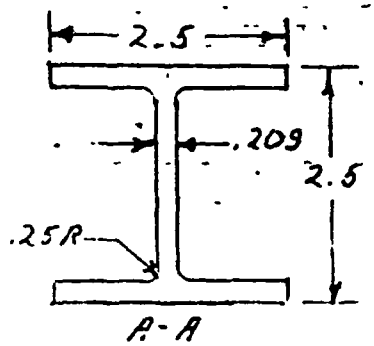
$$V = 26[(1.6)(.85)(2.5)] = 89 \text{ IN}^3$$

TOTAL FRONT SPAR WT = 2(1974)(.101) = 298 LB

* LOAD ON SECTION A-A: 74,000 LB ULTIMATE

RIB TRUSS - 2 REQUIRED Y = ± 17.5





TYPICAL CROSS SECTION

AREA = [2(2.5) + 2.08].209 + 4(.013) = 1.53 IN²

VOLUME OF RIBS:

V = [18.5 + 28 + 28 + 61 + 31.5 + 28 + 63 + 30.5 + 27.5 + 60.5 + 30 + 26.5 + 57 + 27.5 + 24 + 52.5 + 27 + 22 + 17.5 + 20] 1.53 + 2.5[(1.5)(12) + 2(10)] = (681)1.53 + 95

= 1,042 + 95 = 1137 IN³

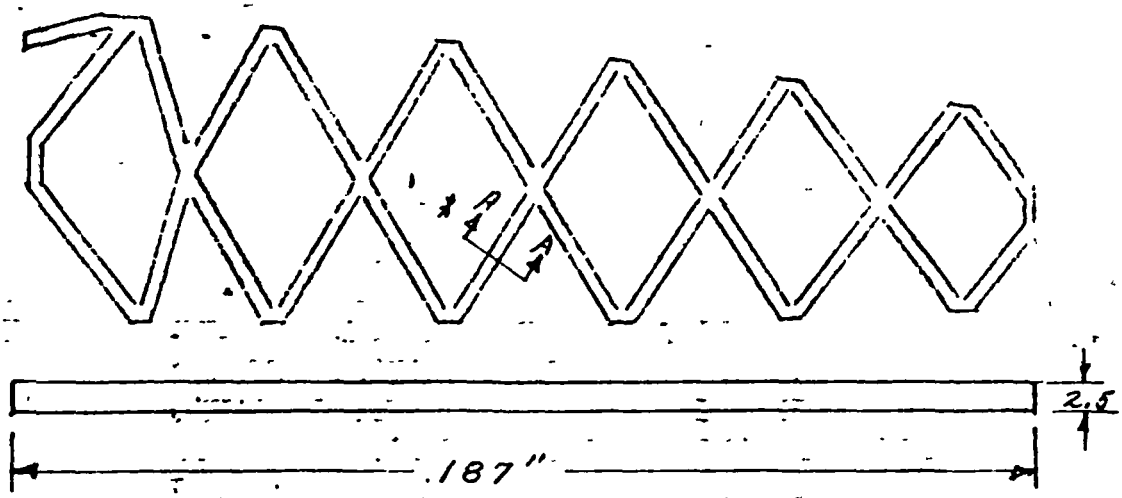
VOLUME OF ATTACH BEEF-UP:

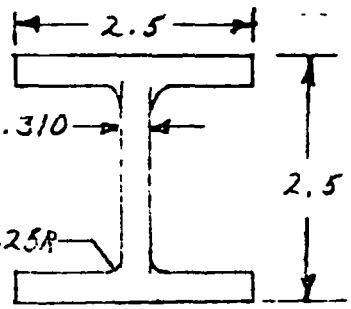
V = [.85(1.6) 2.1] 12 = 35 IN³

TOTAL WT FOR BOTH SIDES = 2(117.2)(.101) = 236 LB

* LOAD ON SECTION A-A: 74,000 LBS ULT.

RIB TRUSS - 2 REQUIRED Y = ± 56





TYPICAL CROSS SECTION

AREA = [2(2.5) + 1.88].310 + 4(.013) = 2.182 IN²

VOLUME OF RIBS:

$V = L^{**}A = (681)^{**}2.182 + 2.5[(1.5)(12) + 2(10)] = 1488 + 95 = 1583\ IN^3$

VOLUME OF ATTACH BEEF-UP:

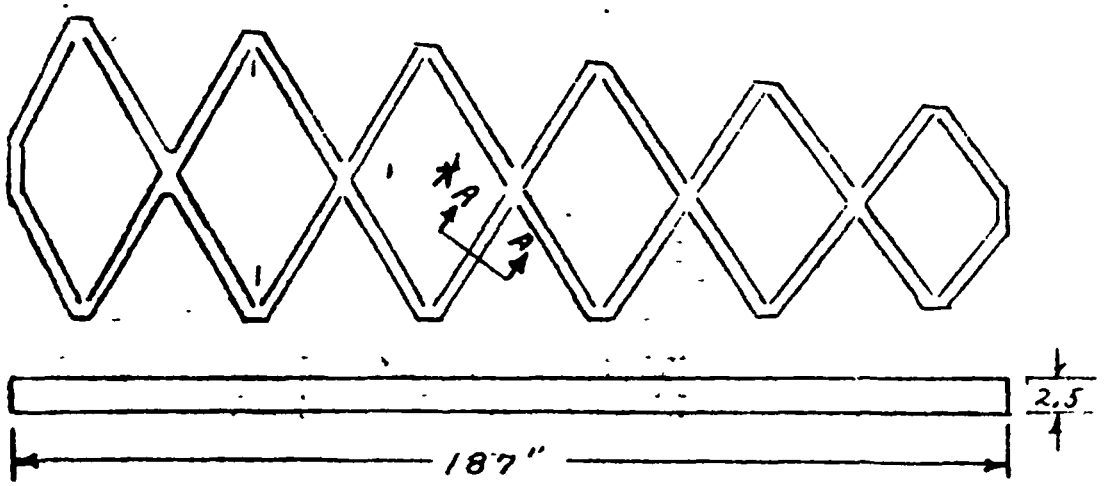
$V = [1(2)(1.88)]12 = 46\ IN^3$

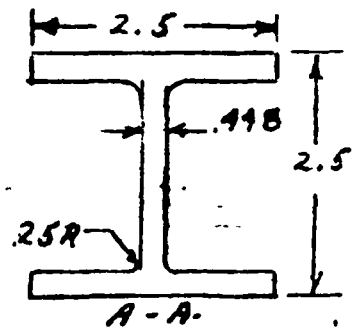
TOTAL WT FOR BOTH SIDES. = 2(1629)(.101) = 324 LB

* LOAD ON SECTION A-A: 106,000 LBS ULT.

** LENGTH OF RIB IS THE SAME AS RIB TRUSS AT Y = ± 17.5

RIB TRUSS - 2 REQUIRED Y= T 168





TYPICAL CROSS SECTION

AREA = [2(2.5) + 1.634](.498) + 4(.013) = 3.022

VOLUME OF RIBS:

$V = [24 + 24 + 65 + 31.5 + 29 + 63 + 30.5 + 27.5 + 60.5 + 30 + 26.5 + 57 + 27.5 + 24 + 52.5 + 27 + 22 + 17.5 + 20]3.022 + 2.5[14.6(2) + 2(10)] = (659)(3.022) + 123$

$= 1990 + 123 = 2113 \text{ IN}^3$

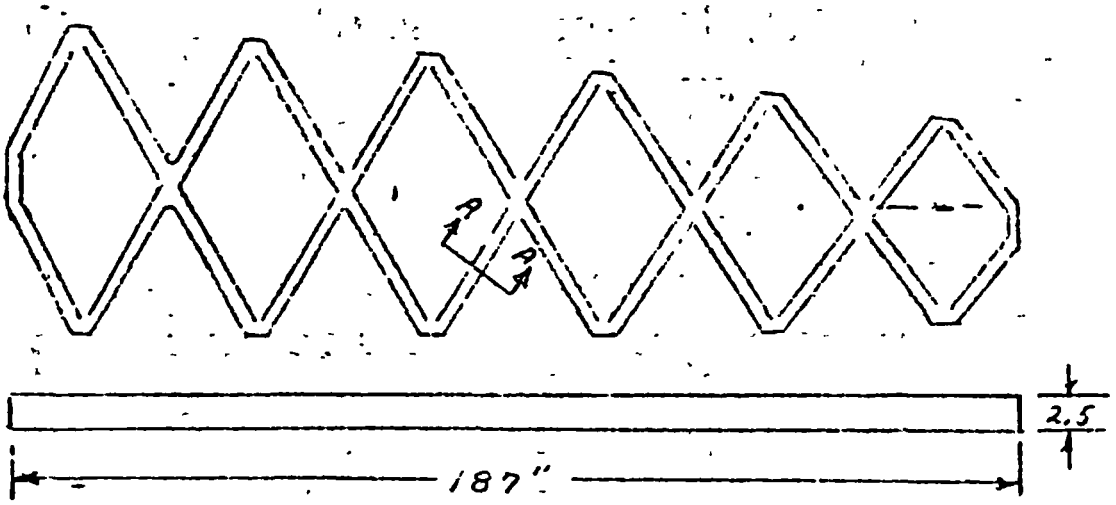
VOLUME OF ATTACH BEEF-UP:

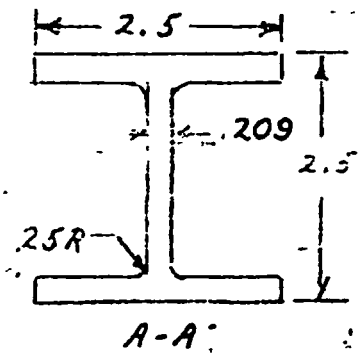
$V = [2(6)(1.634)]12 = 236 \text{ IN}^3$

TOTAL WT FOR BOTH SIDES = 2(2349)(.101) = 474 LB

* LOAD ON SECTION A-A: 148,000 LB ULT

RIB TRUSS - 6 REQUIRED Y = I 92, 128.6, 204





TYPICAL CROSS SECTION

AREA = [2(2.5) + 2.09].209 + 4(.013) = 1.53 IN²

VOLUME OF RIBS:

$V = L^{**}A = 659^{**}(1.53) + 2.5[14.5(2) + 2(10)]$

$= 1008 + 123 = 1131 \text{ IN}^3$

VOLUME OF ATTACH BEEF-UP:

$V = [.85(1.6)(2.1)]12 = 35 \text{ IN}^3$

TOTAL WEIGHT FOR BOTH SIDES = 6(1166)(.101) = 706 LB

* LOAD ON SECTION A-A: 74,000 LB ULT

** LENGTH OF RIB IS THE SAME AS RIB TRUSS AT Y = I 168

LEADING EDGE (½ WING) [4700]

UPPER COVER	961	LB
LOWER COVER	953	
SPAR	377	
RIBS	278	
FORMERS	644	
ATTACH, SPLICES, JOINTS	352	
NOSE	1135	

UPPER COVER

WEIGHT SUMMARY

STRINGERS	.101 X 2895 =	292
SKIN	.101 X 6622 =	669
TOTAL		961

LOWER COVER

STRINGERS	.101 X 2807 =	284
SKIN	.101 X 6622 =	669
TOTAL		953

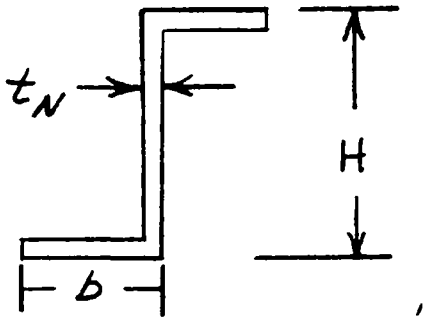
COVER WEIGHT

UPPER COVER	961 LB
LOWER COVER	953 LB
	1914 LB

UPPER COVER (CONT)

STRINGERS

REF: STRESS INPUT SHEET, 899A20105-99 SHT 1 OF 5, 2 OF 8



ROOT – INBOARD

$$\Sigma L = 30+75+70+68+64+56+53+49+43+40+35+31+26+22+20+14+9+5 = 710 \text{ in.}$$

$$A = t_N \times (H + 2\times(b - t_N)) = .10\times(2.85+.65+.4)$$

$$V = \Sigma L \times A = 710 \times .29 = 206 \text{ in}^3$$

ROOT TO RIB NO. 2

FULL LENGTH STRINGERS

$L_{AVG} = 313$ IN $N = 11$

$$A = .10\times\left(.75+.50+\frac{2.65+2.40}{2}\right)$$

$$A = .3775 \text{ in}^2$$

$$V = 313\times11\times.3775 = 1300 \text{ in}^3$$

UPPER COVER (CONT)

STRINGERS (CONT)

ROOT TO NO. 2 RIB (CONT)

PARTIAL LENGTH STRINGERS

$L_{AVG} = 200$ in, $N = 5$

$A = .10 \times [.75 + .5 + \frac{2.65 + 2.5}{2}] = .3825\ in^2$

$V = 5 \times 200 \times .3825 = 383\ in^3$

NO. 2 RIB TO NO. 4 RIB

FULL LENGTH STRINGERS

$L = 236$ in., $N = 7$

$A = .09 \times (.75 + .45 + 2.32) = .3168\ in^2$

$V = 7 \times 236 \times .3168 = 523\ in^3$

PARTIAL LENGTH STRINGERS

$L_{AVG} = 170$ in., $N = 3$

$A = .095 (.75 + .45 + 2.31) = .3335\ in^2$

$V = 3 \times 170 \times .3335 = 170\ in^3$

UPPER COVER (CONT)

STRINGERS (CONT)

No. 4 RIB TO TIP

FULL LENGTH STRINGERS

L_{AVG} = 298 in., N = 3

$A = .07 \times [.75 + .35 + 2.06] = .2212\ in^2$

$V = 298 \times 3 \times .2212 = 198\ in^3$

PARTIAL LENGTH STRINGERS

$L_{AVG} = 117$ in., $N = 4$

$A = .075 \times (.75 + .31 + 2.15) = .2453\ in^2$

$V = 4 \times 117 \times .2453 = 115\ in^3$

TOTAL STRINGERS

$\Sigma V = 206 + 1300 + 383 + 523 + 170 + 198 + 115$

$\Sigma V = 2895\ in^3$

UPPER COVER REF- STRESS INPUT SHEET, 899A2010599 SHT 1 OF 8, 2 OF 8

SKIN 6% CHORD ~ AFT

ROOT TO HINGE RIB NO. 3

$A = 210 \times 85 \times 1/2 + 285 \times 51 \times 1/2 + \frac{155+87}{2} \times 424 = 67497 \text{ in}^2$

$t = .080 \text{ in}$

$V = .08 \times 67497 = 5400 \text{ in}^3$

HINGE RIB NO. 3 TO TIP

$A = \frac{87+36}{2} \times 326 + 38 \times 17 \times 1/2 = 20372 \text{ in}^2$

$t = .06 \text{ in}$

$V = .06 \times 20372 = 1222 \text{ in}^3$

TOTAL

$\Sigma V = 5400 + 1222 = 6622 \text{ in}^3$

LOWER COVER

STRINGERS

ROOT ~ INBOARD

$\Sigma L = 710$ in

$A = .10 \times (.75 + .50 + 2.65) = .390$ in^2

$V = 710 \times .39 = 277$ in^3

ROOT TO NO. 2 RIB

FULL LENGTH STRINGERS

$L_{AVG} = 313$ in., $N = 11$

$A = .10 \times \left(.75 + .50 + \frac{2.65 + 2.20}{2}\right)$

$A = .3675$ in^2

$V = 11 \times 313 \times .3675 = 1265$ in^3

PARTIAL LENGTH STRINGERS

$L_{AVG} = 200$ in., $N = 5$

$A = .10 \times \left(.75 + .50 + \frac{2.65 + 2.35}{2}\right)$

$A = .375$ in^2

$V = 5 \times 200 \times .375 = 375$ in^3

NO. 2 RIB TO NO. 4 RIB

FULL LENGTH STRINGERS

$L = 236$ in, $N = 7$

$A = .09 \times \left(.75 + .45 + \frac{2.18 + 1.92}{2}\right)$

$A = .288$ in^2

$V = 7 \times 236 \times .288 = 476$ in^3

LOWER COVER – STRINGERS

NO. 2 RIB TO NO. 4 RIB (CONT)

PARTIAL LENGTH STRINGERS

$L_{AVG} = 170$ in., $N = 3$

$A = .095 \times (.75 + .45 + 2.11) = .3145\ in^2$

$V = 3 \times 170 \times .3145 = 160\ in^3$

NO. 4 RIB TO TIP

FULL LENGTH STRINGERS

$L_{AVG} = 298$ in., $N = 3$

$A = .07 \times [.75 + .35 + 1.63] = .1911\ in^2$

$V = 298 \times 3 \times .1911 = 171\ in^3$

PARTIAL LENGTH STRINGERS

$L_{AVG} = 117$ in., $N = 4$

$A = .075 \times (.75 + .37 + 1.25) = .1778\ in^3$

$V = 117 \times 4 \times .1778 = 83$

TOTAL STRINGERS

$\Sigma V = 277 + 1265 + 375 + 476 + 160 + 171 + 83$

$\Sigma V = 2807\ in^3$

LOWER COVER

SKIN

$A = 67497\ in^2$

$t = .08$, $V = 67497 \times .08 = 5400\ in^3$

$A = 20372\ in^2$

$t = .06\ in.$, $V = .06 \times 20372 = 1222\ in^3$

TOTAL $= 5400 + 1222 = 6622\ in^3$

LEADING EDGE SPAR

VOLUME- WEIGHT CONVERSION

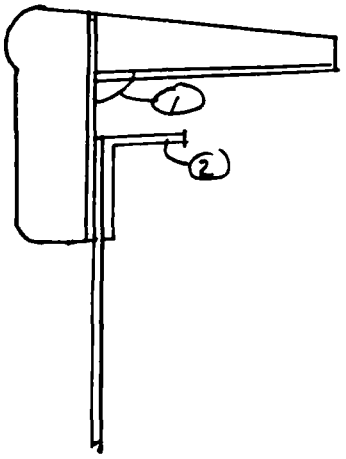
CAPS	.101X1668 =	168
WEB	.101X1258 =	127
WEB STIFFENERS	.101X 711 =	72
BODY ATTACH FTG (EST)		10
TOTAL		377 LB

LEADING EDGE SPAR 377 LB.

LEADING EDGE SPAR

CAPS

REF. STRESS INPUT, 899 A2010 599, SHT 1 OF 8
7 OF 8



$V_{①} = 2.85 \times .125 + 1.0 \times .125 + .8 \times 2.5 \times .125 \div 7.5$
$+ (3.5 \times 1.0 \times .18 + .4 \times 1.7 \times .125) \div 7.5$
$= .61 \text{ in}^3/\text{in}$

$V_{②} = 2.5 \times .1 = .25$

$\Sigma V_{\substack{\text{UPPER} \\ \& \text{LOWER} \\ \text{CAP}}} = 970 \times (.25 + .61) \times 2 = 1668 \text{ in}^3$

LEADING EDGE SPAR

WEB

REF: STRESS INPUT, 879M2010599 SHT 1 OF 8, 7 OF 8

INBOARD TO ROOT

$t = .08''$, $L = 95$ in., $H_{AVG} = 32$ in

$V = .08 \times 95 \times 32 = 243 \text{ in}^3$

ROOT TO 0 RIB

$V = \frac{120}{6} \times (.08 \times 27.2 + .07 \times 25.3 + 4 \times .075 \times 26.2)$

$= 236 \text{ in}^3$

0 RIB TO No. 1 RIB

$V = \frac{154}{6} (.07 \times 25.3 + .05 \times 23.1 + .06 \times 4 \times 24.2)$

$= 234 \text{ in}^3$

No. 1 RIB TO No. 2 RIB

$V = \frac{122}{6} \times (.05 \times 23.1 + .05 \times 21.2 + 4 \times .05 \times 22.2)$

$= 135 \text{ in}^3$

No. 2 RIB TO No. 3 RIB

$V = \frac{154}{6} \times (.05 \times 21.2 + .04 \times 18.8 + 4 \times .045 \times 20)$

$= 139 \text{ in}^3$

No. 3 RIB TO No. 4 RIB

$V = \frac{86}{6} \times (.04) \times (18.8 + 17.4 + 4 \times 18.1)$

$= 62 \text{ in}^3$

No. 4 RIB TO No. 5 RIB

$V = \frac{120}{6} \times (.04 \times 17.4 + .05 \times 15.6 + 4 \times .045 \times 16.5)$

$= 89 \text{ in}^3$

LEADING EDGE SPAR

WEB

NO. 5 RIB TO TIP

$$V = \frac{145}{6} \times (.05 \times 15.6 + .06 \times 13.6 + 4 \times .065 \times 14.6)$$

$$= 130 \text{ in}^3$$

TOTAL

$$\Sigma V = 293 + 236 + 224 + 135 + 139 + 62 + 89 + 130$$
$$= 1258 \text{ in}^3$$

WEB STIFFENERS

$$A = 1.2 \times .10 + 1.3 \times .10 = .25 \text{ in}^2$$

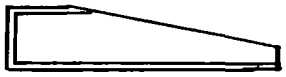
$$H_{AVG} = 22 \text{ in.}$$

$$V = (970 \div 7.5) \times 22.0 \times .25 = 711 \text{ in}^3$$

LEADING EDGE

ATTACHMENT PROVISIONS FOR HOT STRUCTURE NOSE

RIB FITTING REF 899A2010599 SHT 7 OF 8



$V = 10.1 \times 1.75 \times .1 + .8 \times 9 \times .15 + 1.2 \times 1.85 \times .15 = 2.58\ in^3$

$\Sigma V = 2 \times 9 \times 2.58 = 46\ in^3$

FORMER FITTINGS

$V = 7.5 \times 2 \times .08 \times 1.75 + 1.4 \times 7.8 \times .15 + 1.75 \times 1.5 \times .1 = 4\ in^3$

$V = 2 \times 25 \times 4 = 200\ in^3$

$\Sigma V = 46 + 200 = 246\ in^3$

WEIGHT SUMMARY

FITTINGS	$.101 \times 246 =$	25 LB
ATTACH		3
TOTAL		28 LB

RIBS & FORMERS

VOLUME-WEIGHT CONVERSION

ROOT RIB	.101 ×	695	=	70
0 RIB	.101 ×	501	=	51
NO. 1 RIB	.101 ×	408	=	41
NO. 2 RIB	.101 ×	354	=	36
NO. 3 RIB	.101 ×	251	=	25
NO. 4 RIB	.101 ×	233	=	24
NO. 5 RIB	.101 ×	154	=	16
TIP RIB	.101 ×	151	=	15
TOTAL RIBS				278

FORMERS .101 × 6379 = 644 LB

RIBS [illegible] 3 OF 3, 4 OF 3
7 OF 8, 8 OF 8

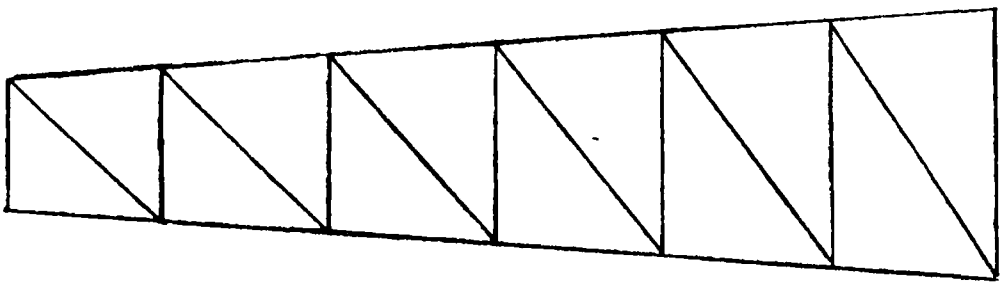
FORWARD DEPTH , AFT DEPTH

$\frac{34-19}{880} = .017$ IN/IN $\frac{63-29}{777} = .04376$ IN/IN

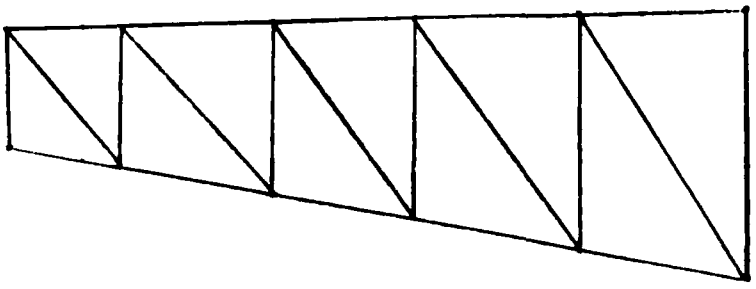
RIB	SPAN	DEPTH	LESS TPS	LESS STR	SPAN	DEPTH	LESS TPS	LESS STR
ROOT	0	34	30	27.2	0	63	59.1	56.3
0	118	32.0	28	25.3	0	63	59.1	56.3
1	271	29.4	25.5	23.1	152	56.3	52.4	49.8
2	394	27.3	23.4	21.2	274	51.0	47.1	44.7
3	546	24.7	20.8	18.8	424	44.4	40.5	38.4
4	633	23.2	19.3	17.4	509	40.7	36.8	34.8
5	755	21.2	17.3	15.6	629	35.5	31.6	29.8
TIP	880	19	15.1	13.6	777	29	25.1	23.6

SCALE: 1" = 40"

ROOT RIB



0 RIB



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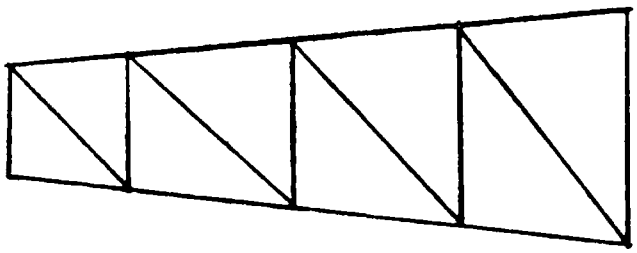
2.1-39

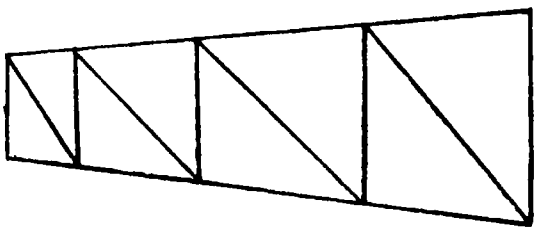
2.1-39

RIBS

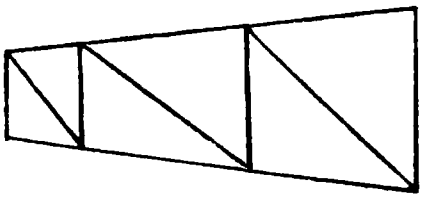
No 1 RIB



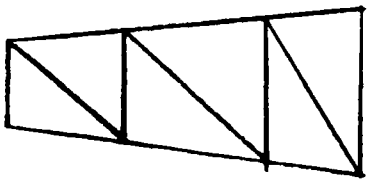
No. 2 RIB



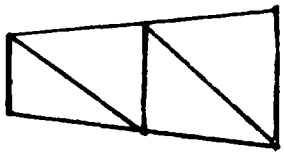
No. 3 RIB



No. 4 RIB

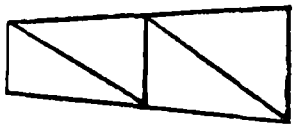


No. 5 RIB



RIBS

TIP RIB



RIBS (CONT.)

REF. MMC 899A2010616

CAP AREA = .50 in^2

VERTICAL MEMBER AREA = .90 in^2

DIAGONAL MEMBER AREA = .90 in^2

END EDGE MEMBER AREA ≈ .4

ROOT RIB

UPPER & LOWER CAPS

$\Sigma L = 208 + 208 = 416$ in.

$V = 416 \times .50 = 208\ in^3$

VERTICAL MEMBERS

$\Sigma L = 50 + 45 + 40 + 35 + 30 = 200$ in.

$V = 200 \times .90 = 180\ in^3$

DIAGONAL MEMBERS

$\Sigma L = 62 + 58 + 55 + 51 + 48 + 42 = 316$ in.

$V = 316 \times .90 = 284\ in^3$

END EDGE MEMBERS

$V = .28 \times 81 = 23\ in^3$

UPPER & LOWER CAPS	208
VERTICAL MEMBERS	180
DIAGONAL MEMBERS	284
END EDGE MEMBERS	23
TOTAL	695 in^3

RIBS (CONT.)

O RIB

UPPER & LOWER CAPS

$\Sigma L = 155 + 155 = 310$ in

$V = 310 \times .50 = 155$ in^3

VERTICAL MEMBERS

$\Sigma L = 50 + 40 + 35 + 28 = 153$ in.

$V = 153 \times .90 = 138$ in^3

DIAGONAL MEMBERS

$\Sigma L = 62 + 58 + 55 + 30 = 205$ in.

$V = 205 \times .90 = 185$ in^3

ATTACHMENTS

USE SAME ATTACHMENTS AS TORQUE BOX ATTACHMENTS

$V = .28 \times 81 = 23$

UPPER & LOWER CAPS	155
VERTICAL MEMBERS	138
DIAGONAL MEMBERS	185
END EDGE MEMBERS	23
TOTAL	501

RIBS (CONT)

No. 1 RIB

UPPER & LOWER CAPS

$\Sigma L = 130 + 130 = 260$ in

$V = 260 \times .5 = 130$ in^3

VERTICAL MEMBERS

$\Sigma L = 41 + 39 + 27 = 102$ in

$V = 102 \times .90 = 92$ in^3

DIAGONAL MEMBERS

$\Sigma L = 56 + 50 + 44 + 34 = 184$ in.

$V = 184 \times .9 = 168$ in^3

END EDGE MEMBERS

$V = .28 \times 66 = 18$

UPPER & LOWER CAPS	130
VERTICAL MEMBERS	92
DIAGONAL MEMBERS	168
END EDGE MEMBERS	18
	408

RIBS (CONT)

NO. 2 RIB

UPPER & LOWER CAPS

$\Sigma L = 111 + 111 = 222$ in.

$V = 222 \times .50 = 111$ in^3

VERTICAL MEMBERS

$\Sigma L = 36 + 29 + 24 = 89$ in.

$V = 89 \times .9 = 81$ in^3

DIAGONAL MEMBERS

$\Sigma L = 52 + 46 + 36 + 27 = 161$ in

$V = 161 \times .90 = 145$ in^3

END EDGE MEMBERS

$V = .28 \times 62 = 17$

UPPER & LOWER CAPS	111
VERTICAL MEMBERS	81
DIAGONAL MEMBERS	145
END EDGE MEMBERS	17
TOTAL	354 in^3

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RIBS (CONT)

No. 3 RIB

UPPER & LOWER CAPS

$\Sigma L = 86 + 88 = 174$ in.

$V = 174 \times .5 = 87$ in^3

VERTICAL MEMBERS

$\Sigma L = 30 + 20 = 50$ in

$V = 50 \times .9 = 45$ in^3

DIAGONAL MEMBERS

$\Sigma L = 50 + 40 + 25 = 115$ in

$V = 115 \times .9 = 104$ in^3

END EDGE MEMBERS

$V = .28 \times 52 = 15$ in^3

UPPER & LOWER CAPS	87
VERTICAL MEMBERS	45
DIAGONAL MEMBERS	104
END EDGE MEMBERS	15
TOTAL	251

RIBS

NO. 4 RIB

UPPER & LOWER CAPS

$\Sigma L = 75 + 75 = 150$ in

$V = 150 \times .5 = 75$ in^3

VERTICAL MEMBERS

$\Sigma L = 30 + 23 = 53$

$V = 53 \times .90 = 48$ in^3

DIAGONAL MEMBERS

$\Sigma L = 35 + 40 + 30 = 105$ in.

$V = 105 \times .90 = 95$ in^3

END EDGE MEMBERS

$V = .28 \times 52 = 15$ in^3

UPPER & LOWER CAPS	75
VERTICAL MEMBERS	48
DIAGONAL MEMBERS	95
END EDGE MEMBERS	15
TOTAL	233

RIBS (CONT)

No. 5 RIB

UPPER & LOWER CAPS

$\Sigma L = 55 + 57 = 112$ in

$V = 112 \times .5 = 56$ in^3

VERTICAL MEMBERS

$\Sigma L = 21$ in.

$V = 21 \times .90 = 19$ in^3

DIAGONAL MEMBERS

$\Sigma L = 40 + 32 = 72$ in.

$V = 72 \times .9 = 65$ in^3

END EDGE MEMBERS

$V = 50 \times .28 = 14$ in^3

UPPER & LOWER CAPS	56
VERTICAL MEMBERS	19
DIAGONAL MEMBERS	65
END EDGE MEMBERS	14
TOTAL	154 in^3

RIBS

TIP RIB

UPPER & LOWER CAPS

$\Sigma L = 60+60 = 120$ in.

$V = 120 \times .50 = 60\ in^3$

VERTICAL MEMBERS

$\Sigma L = 19$ in

$V = 19 \times .90 = 17\ in^3$

DIAGONAL MEMBERS

$\Sigma L = 35+34 = 69$ in.

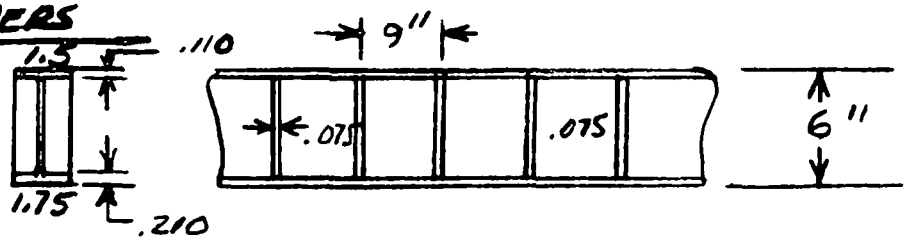
$V = 69 \times .9 = 62\ in^3$

END EDGE MEMBERS

$V = .28 \times 43 = 12\ in^3$

UPPER & LOWER CAPS	60
VERTICAL MEMBERS	17
DIAGONAL MEMBERS	62
END EDGE MEMBERS	11
TOTAL	151

FORMERS



$V = 5.68 \times .075 + 1.5 \times .110 + 1.5 \times .210$
$+ 1.55 \times 5.68 \times .075 \div 9$
$= .98 \ in^3/in$

Σ FORMER LENGTH UPPER & LOWER BETWEEN BODY INTERSECTION & O RIB AND BETWEEN NO. 2 RIB AND TIP

$\Sigma L = 2738$ in.

$V = .98 \times 2738 = 2680 \ in^3$

CLIPS – FORMER TO SPAR

$V = 6 \times .3 \times .125 \times 4 = 9 \ in^3$

$N_F = 19$

$\Sigma V = 19 \times 9 = 171 \ in^3$

USE FORMER AT BODY INTERSECTION

$V = 570 \times .98 + 9 = 569 \ in^3$

$\Sigma V = 2680 + 171 + 569 = 3420 \ in^3$

FORMERS – INBOARD OF RIB 2

USE TRUSS STRUCTURE AS IN RIBS BETWEEN 0 RIB AND RIB NO. 2

0 RIB $V = 501\ in^3$

NO. 1 RIB $V = 408\ in^3$

$AVG = 909 \div 2 = 454\ in^3$

$N = 4$

$\Sigma V = 4 \times 454 = 1816\ in^3$

NO. 1 RIB $V = 408\ in^3$

NO. 2 RIB $V = 354\ in^3$

$V_{AVG} = (408 + 354) \div 2 = 762 \div 2 = 381\ in^3$

$N = 3$

$\Sigma V = 3 \times 381 = 1143\ in^3$

TOTAL FORMERS

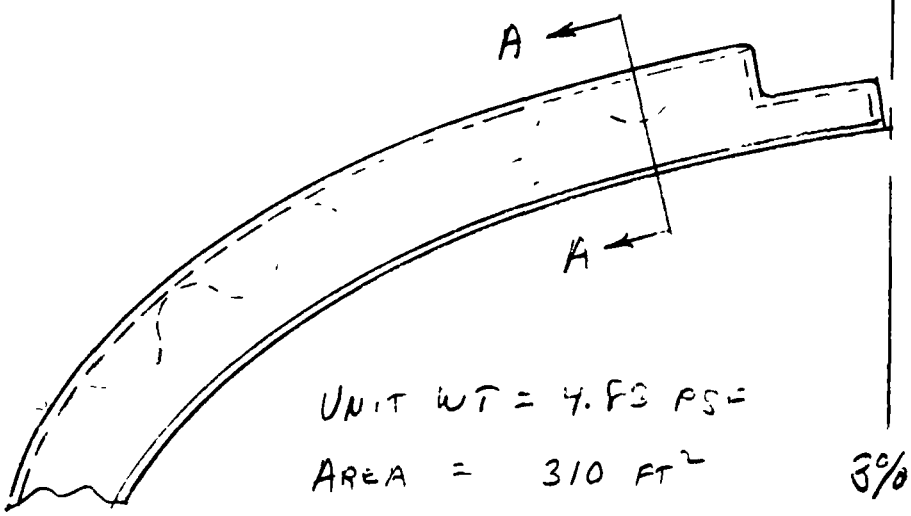
$\Sigma V = 3420 + 1816 + 1143 = 6379\ in^3$

LEADING EDGE

TOTAL ATTACHMENTS, JOINTS, SPLICES

COVERS	200	LB.
SPAR	38	
RIBS & FORMERS	86	
NOSE	28	
TOTAL		352 LB

WING LEADING EDGE NOSE

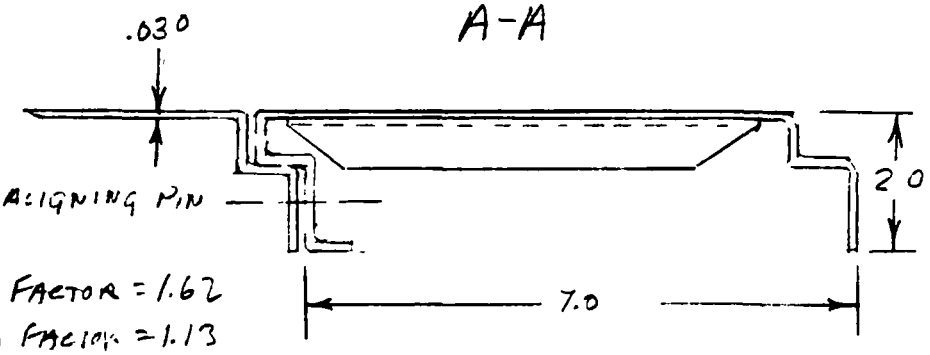


UNIT WT = 4.63 PSF

AREA = 310 FT² 3% C

WT = 1497 LBS

A-A



SPAN AREA FACTOR = 1.62
CHORD AREA FACTOR = 1.13

		PSF
SKIN .030 COLUMBIUM ρ = .38		
(7 X 1.62)(23 X 1.13) .030 X .38 / 1.11		3.029
CORRUGATION .025 COL		
(5 X 14 X 1.4 X .025 X .38 / 1.11)		.839
COATING .0012 PSI		
((7 X 1.62)(23 X 1.13) − 5 X 14 X 1.4) 1.11 X .0012		.721
ATTACHMENTS		
BOLTS, NUTS	.033 X 2 = .066	
LUGS	.068 X 2 = .136	
ALIGNING PIN	.016 X 4 = .064	
	.266 / 1.11	.240
CONTINGENCY 10%		.303

WING LEADING EDGE (CON'T)

REMAINING AREA OF 310 FT² FOR HCF BACKUP IS 2.5 LB/FT² WETTED AREA.

BACKUP STRUCTURE

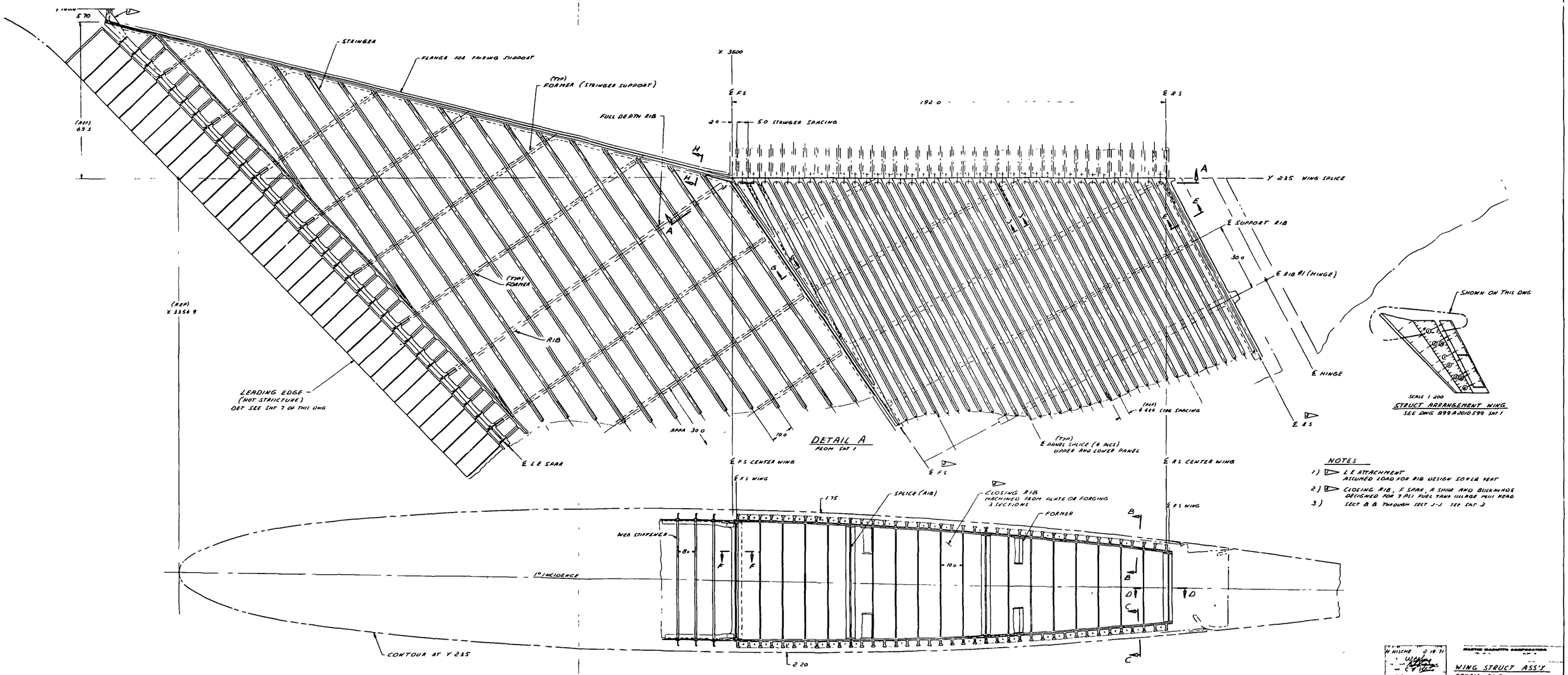
WT = 310 X 2.5 = 773 LB

HOT STRUCTURE

WT = 310 X 4.83 = 1497 LB

TOTAL LEADING EDGE NOSE 2270 LB

1/2 WING LEADING EDGE 1135 LB


STRINGER
FLANGE FOR FAIRING SUPPORT
(TYP) FORMER (STRINGER SUPPORT)
FULL DEPTH RIB
X 3600
℄ F S
℄ R S
192 0
2 0
5 0 STRINGER SPACING
Y 235 WING SPLICE
℄ SUPPORT RIB
30 0
℄ RIB #1 (HINGE)
℄ HINGE
(REF) 69 3
(REF) X 3354 9
(TYP) FORMER
RIB
LEADING EDGE (HOT STRUCTURE) DET SEE SHT 7 OF THIS DWG
APPR 30 0
10 0
℄ L E SPAR
DETAIL A
FROM SHT 1
(TYP) ℄ PANEL SPLICE (4 PLCS) UPPER AND LOWER PANEL
(REF) 4 424 STRG SPACING
℄ F S CENTER WING
℄ F S WING
℄ R S CENTER WING
℄ R S WING
SHOWN ON THIS DWG
SCALE 1 200
STRUCT ARRANGEMENT WING
SEE DWG 899A2010599 SHT 1
NOTES
1) L E ATTACHMENT ASSUMED LOAD FOR RIB DESIGN 50 KLB VERT
2) CLOSING RIB, F SPAR, A SPAR AND BULKHEADS DESIGNED FOR 7 PSI FUEL TANK ULLAGE PLUS HEAD
3) SECT B B THROUGH SECT J-J SEE SHT 3
1 75
SPLICE (RIB)
CLOSING RIB MACHINED FROM PLATE OR FORGING 3 SECTIONS
FORMER
WEB STIFFENER
8 0
10 0
1° INCIDENCE
CONTOUR AT Y 235
2 20
SECT A - A
H HISCHE 2 19 71
MARTIN MARIETTA CORPORATION
WING STRUCT ASS'Y
CONFIG 20 B
WING - BOOSTER SPLICE
04236 899A2010599
1 10
1" 2 of 8

TORQUE BOX

COVERS

UPPER SKIN	2320
LOWER SKIN	2334
SKIN	4654
UPPER STRINGERS	2730
LOWER STRINGERS	1523
STRINGERS	4253

UPPER COVER

VOLUME-WEIGHT CONVERSION SUMMARY

			TOTAL WING
STRINGERS			
STRINGERS	26476 X .101 =	2674	5348
FILLETS	430 X .101 =	43	86
INB'D BEEF-UP	130 X .101 =	13	26
TOTAL		2730	5460
SKIN			
SKIN	21369 X .101 =	2158	4316
INB'D BEEF-UP	92 X .101 =	9	18
INB'D ATTACH FLANGE	720 X .101 =	73	146
OUTB'D ATTACH FLANGE	322 X .101 =	33	66
AFT SPAR ATTACH BEEF-UP	464 X .101 =	47	94
		2320	4640
SKIN SPLICE STRAPS			
STRAPS	707 X .101 =	71	142
SKIN & SPLICE STRAP ATTACH			
SPLICE STRAP ATTACH	89 X .286 + 56 X (.286-.101) =	36	72
SKIN SPLICE ATTACH	89 X .286 + 56 X (.286-.101) =	36	72
		143	286

UPPER COVER

Summary

$$\Sigma V_{STRINGERS} = 3457+3206+217+195+3056+3041+94+103+3544+3506+1281+1396+52+56+1287+1187+41+41+364+352$$

$$= 26476\ in^3$$

$$\Sigma V_{SKIN} = 4878+4814+7404+3402+871$$

$$= 21369\ in^3$$

$$\Sigma V_{FILLETS} = 430\ in^3$$

$$\Sigma V_{\substack{INBOARD\\STRINGER\\BEEF-UP}} = 130\ in^3$$

$$\Sigma V_{\substack{INBOARD\\SKIN\\BEEF-UP}} = 92\ in^3$$

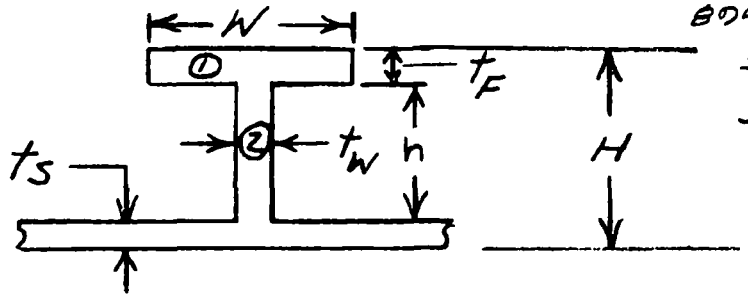
$$\Sigma V_{\substack{INBOARD\\ATTACH\\FLANGE}} = 720\ in^3$$

$$\Sigma V_{\substack{OUTBOARD\\ATTACH\\FLANGE}} = 522\ in^3$$

$$\Sigma U_{\substack{AFT\ SPAR\\ATTACH\\BEEF-UP}} = 464\ in^3$$

UPPER COVER STRINGERS

REF STRESS INPUT
B09A20105-99
SH 1 OF 8, 4 OF 8
3 OF 8,



VOLUME OF ① & ② IS CALCULATED USING PRISMOID VOLUME FORMULA:

$$V = \frac{L}{6}\left[A_0 + A_1 + 4A_M\right]$$

ROOT TO RIB NO. 1

L_{AVG} = 103 IN.

W_0 =	1.75	t_{F_0} =	.60
W_1 =	1.68	t_{F_1} =	.52
W_M =	1.71	t_{F_M} =	.56
t_{W_0} =	.50	t_{S_0} =	.3
t_{W_1} =	.42	t_{S_1} =	.274
t_{W_M} =	.46	t_{S_M} =	.287

$H_0 = 2.85$, $h_0 = H_0 - (t_{S_0} + t_{F_0}) = 1.95$
$H_1 = 2.71$, $h_1 = 1.916$
$H_M = 2.78$, $h_M = 1.933$

UPPER COVER STRINGERS (CONT)

ROOT TO RIB NO 1 (CONT)

$$A_{①i} = W_i \times t_{Fi}\ ,\ A_{②i} = h_i \times t_{Wi}$$

$$V_① = n \times \frac{L_{AVG}}{6}\left[A_{①0} + A_{①1} + 4A_{①m}\right]$$

$$V_② = n \times \frac{L_{AVG}}{6}\left[A_{②0} + A_{②1} + 4A_{②m}\right]$$

$$V_① = 35 \times \frac{103}{6} \times \left[1.75 \times .60 + 1.68 \times .52 + 4 \times 1.71 \times .56\right] = 3457\ in^3$$

$$V_② = 35 \times \frac{103}{6}\left[1.95 \times .50 + 1.916 \times .42 + 4 \times 1.933 \times .46\right] = 3206\ in^3$$

RIB NO. 1 TO RIB NO. 2

FULL SECTION $L = 120''$

$W_0 = 1.68$	$t_{F0} = .52$
$W_1 = 1.60$	$t_{F1} = .45$
$W_m = 1.64$	$t_{Fm} = .485$
$t_{w0} = .52$	$t_{s0} = .274$
$t_{w1} = .35$	$t_{s1} = .25$
$t_{wm} = .405$	$t_{sm} = .262$
$H_0 = 2.71$	$h_0 = 1.916$
$H_1 = 2.60$	$h_1 = 1.900$
$H_m = 2.655$	$h_m = 1.908$

UPPER COVER STRINGERS (CONT)

RIB NO. 1 TO RIB NO. 2 (CONT)

$$V_{①} = 32 \times \frac{120}{6} \times [1.68 \times .52 + 1.60 \times .45 + 1.64 \times .485 \times 4] = 3056 \text{ in}^3$$

$$V_{②} = 32 \times \frac{120}{6} \times [.52 \times 1.916 + .35 \times 1.90 + .405 \times 1.908 \times 4] = 3041 \text{ in}^3$$

VARIABLE LENGTH RIBS ~ ROOT TO NO. 1 RIB

$$V_{①} = \frac{110}{6}[1.75 \times .60 + .57 \times 1.72 + 4 \times .58 \times 1.73] + \frac{65}{6}[1.75 \times .60 + 1.72 \times .58 + 4 \times .59 \times 1.74] + \frac{38}{6}[1.75 \times .60 + 1.74 \times .59 + 4 \times .595 \times 1.745]$$

$$= 217 \text{ in}^3$$

$$V_{②} = \frac{110}{6}[1.95 \times .5 + 1.935 \times .44 + 4 \times .47 \times 1.99] + \frac{65}{6}[1.95 \times .5 + 1.94 \times .45 + 4 \times .475 \times 1.94] + \frac{38}{6}[1.95 \times .5 + 1.94 \times .46 + 4 \times .48 \times 1.945]$$

$$= 195 \text{ in}^3$$

UPPER COVER STRINGERS (CONT)

RIB NO. 2 TO RIB NO. 4

FULL SECTION $L = 234.$

$W_0 =$	1.60	$t_{F_0} =$	.45
$W_1 =$	1.50	$t_{F_1} =$	.30
$W_M =$	1.55	$t_{F_M} =$	.375
$t_{W_0} =$	.350	$t_{S_0} =$	.25
$t_{W_1} =$	.275	$t_{S_1} =$	.225
$t_{W_M} =$	.3125	$t_{S_M} =$	.2375
$H_0 =$	2.60	$h_0 =$	1.900
$H_1 =$	2.32	$h_1 =$	1.783
$H_M =$	2.46	$h_M =$	1.842

$$V_① = 26 \times \frac{234}{6} \times [1.6 \times .45 + 1.50 \times .30 + 1.55 \times .375 \times 4] = 3544 \text{ in}^3$$

$$V_2 = 26 \times \frac{234}{6} \times [.35 \times 1.9 + .275 \times 1.783 + .3125 \times 4 \times 1.842] = 3506 \text{ in}^3$$

UPPER COVER STRINGERS (CONT)

VARIABLE LENGTH STRINGERS RIB NO. 1 TO RIB NO 2

$$V_{①} = \frac{75}{6}[1.68 \times .52 + 1.66 \times .47 + 4 \times 1.67 \times .495] + \frac{38}{6}[1.68 \times .52 + 1.65 \times .50 + 4 \times 1.665 \times .51]$$

$$= 94 \text{ in}^3$$

$$V_{②} = \frac{75}{6}[1.916 \times .52 + 1.905 \times .42 + 4 \times 1.910 \times .47] + \frac{38}{6}[1.916 \times .52 + 1.91 \times .47 + 4 \times 1.913 \times .49]$$

$$= 103 \text{ in}^3$$

RIB NO. 4 TO ACT. OUTB'D

FULL SECTION $L = 135$ in

$W_o = 1.50$	$t_{F_o} = .30$
$W_1 = 1.50$	$t_{F_1} = .25$
$W_m = 1.50$	$t_{F_m} = .275$
$t_{w_o} = .275$	$t_{s_o} = .225$
$t_{w_1} = .250$	$t_{s_1} = .225$
$t_{w_m} = .2625$	$t_{s_m} = .225$
$H_o = 2.32$	$h_o = 1.783$
$H_1 = 2.10$	$h_1 = 1.625$
$H_m = 2.21$	$h_m = 1.715$

UPPER COVER STRINGERS (CONT)

RIB NO 4 TO AFT. OUTB'D

$$V_{①} = 23 \times \frac{135}{6} \times [1.50 \times .30 + 1.5 \times .25 + 4 \times 1.50 \times .275] = 1281 \text{ in}^3$$

$$V_{②} = 23 \times \frac{135}{6} \times [.275 \times 1.783 + .250 \times 1.625 + .2625 \times 1.715 \times 4] = 1396 \text{ in}^3$$

VARIABLE LENGTH STRINGERS NO. 4 TO AFT OUTB'D

$$V_{①} = \frac{80}{6}[1.5 \times .3 + 1.5 \times .265 + 1.5 \times .283 \times 4] + \frac{40}{6}[1.5 \times .3 + 1.5 \times .285 + 4 \times .292 \times 1.5]$$

$$= 52 \text{ in}^3$$

$$V_{②} = \frac{80}{6}[1.783 \times .275 + 1.68 \times .258 + 1.73 \times .267 \times 4] + \frac{40}{6}[1.783 \times .275 + 1.73 \times .267 + 1.755 \times .271 \times 4]$$

$$= 56 \text{ in}^3$$

UPPER COVER STRINGERS

ACT. OUTB'D TO TIP

FULL SECTION $\ell_{AVG} = 143$ in

$W_0 = 1.50$		$t_{F_0} = .25$	
$W_1 = 1.50$		$t_{F_1} = .35$	
$W_m = 1.50$		$t_{F_m} = .30$	
$t_{w_0} = .250$		$t_{s_0} = .225$	
$t_{w_1} = .30$		$t_{s_1} = .250$	
$t_{w_m} = .275$		$t_{s_m} = .2375$	
$H_0 = 2.10$		$h_0 = 1.625$	
$H_1 = 2.00$		$h_1 = 1.40$	
$H_m = 2.05$		$h_m = 1.513$	

$$V_{①} = 20 \times \frac{143}{6} \times [1.50 \times .25 + 1.5 \times .35 + 4 \times 1.5 \times .30] = 1269 \text{ in}^3$$

$$V_{②} = 20 \times \frac{143}{6} \times [.25 \times 1.625 + .30 \times 1.40 + .275 \times 4 \times 1.513]$$
$$= 1187 \text{ in}^3$$

VARIABLE LENGTH STRINGERS – ACT. OUTB'D TO TIP

$$V_{①} = \frac{70}{6}(1.5 \times .25 + 1.50 \times .30 + .275 \times 1.50 \times 4]$$
$$+ \frac{30}{6}(1.5 \times .25 + 1.5 \times .28 + 1.5 \times .265 \times 4]$$
$$= 41 \text{ in}^3$$

$$V_{②} = \frac{70}{6}(1.625 \times .25 + 1.51 \times 2.75 + 4 \times 1.56 \times .262)$$
$$+ \frac{30}{6}(1.625 \times .25 + 1.56 \times .265 + 1.59 \times .257 \times 4)$$
$$= 41 \text{ in}^3$$

UPPER COVER STRINGERS (CONT)

VARIABLE LENGTH STRINGERS NO 2 RIB TO NO. 4

$$V_{①} = \frac{200}{6}[1.60\times.45 + 1.51\times.33 + 4\times.39\times1.55]$$
$$+ \frac{150}{6}[1.6\times.45 + 1.53\times.39 + 4\times1.565\times.39]$$
$$+ \frac{112}{6}[1.6\times.45 + 1.55\times.37 + 4\times1.575\times.41]$$
$$+ \frac{78}{6}[1.6\times.45 + 1.57\times.40 + 4\times1.585\times.425]$$
$$+ \frac{38}{6}[1.6\times.45 + 1.585\times.43 + 4\times1.592\times.44]$$
$$= 369.1^3$$

$$V_{②} = \frac{200}{6}[1.90\times.35 + 1.8\times.283 + 1.85\times4\times.315]$$
$$+ \frac{150}{6}[1.90\times.35 + 1.82\times.30 + 1.86\times4\times.325]$$
$$+ \frac{112}{6}[1.90\times.35 + 1.84\times.312 + 1.87\times4\times.331]$$
$$+ \frac{78}{6}[1.90\times.35 + 1.865\times.328 + 1.87\times4\times.339]$$
$$+ \frac{38}{6}[1.90\times.35 + 1.88\times.34 + 1.89\times4\times.345]$$
$$= 352 in^3$$

UPPER COVER SKIN STRESS INPUT, 899A2010 597 SHT 1 OF 8,

ROOT TO RIB NO 1

$t_{s_0} = .29$, $C_0 = 168$
$t_{s_1} = .274$, $C_1 = 160$
$t_{s_m} = .282$ $C_m = 164$

$$V = \frac{60}{6}\left[.29 \times 168 + .274 \times 160 + .282 \times 164 \times 4\right]$$
$$+ 190 \times 75 \times \tfrac{1}{2} \times .295 = 4878\ in^3$$

RIB NO 1 TO RIB NO 2

$t_{s_0} = .274$ $C_0 = 160$
$t_{s_1} = .25$ $C_1 = 146$
$t_{s_m} = .262$ $C_m = 153$

$$V = \frac{120}{6}\left[.274 \times 160 + .25 \times 146 + .262 \times 153 \times 4\right]$$
$$= 4814\ in^3$$

RIB NO 2 TO RIB NO 4

$t_{s_0} = .25$ $C_0 = 146$
$t_{s_1} = .225$ $C_1 = 120$
$t_{s_m} = .2375$ $C_m = 133$

$$V = \frac{239}{6}\left[.25 \times 146 + .225 \times 120 + .2375 \times 133 \times 4\right]$$
$$= 7404\ in^3$$

UPPER COVER SKIN

RIB NO. 4 TO ACT. OUTB'D

$t_{s_0} = .225$ $\quad c_0 = 120$

$t_{s_1} = .225$ $\quad c_1 = 109$

$t_{s_m} = .225$ $\quad c_m = 112$

$$V = \frac{135}{6}\left[.225 \times 120 + .225 \times 104 + .225 \times 112 \times 4\right] = 3402$$

ACT OUTB'D TO TIP

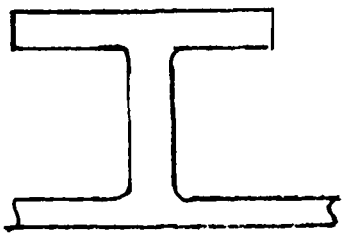
$t_{s_0} = .225$ $\quad c_0 = 104$

$t_{s_1} = .250$ $\quad c_1 = 85$

$t_{s_m} = .2375$ $\quad c_m = 94$

$$V = \frac{39}{6}\left[225 \times 104 + .25 \times 85 + 4 \times 94 \times .2375\right] = 871$$

STRINGER FILLETS

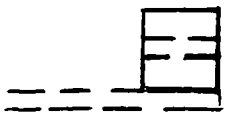


$\Sigma L = 20650$ in.

$$V = .2146 \times .156^2 \times 20650 \times 4 = 430 \text{ in}^3$$

WING-BODY ATTACH FLANGE REF 89A2010599 SHT 1 OF 8, 3 OF 8

UPPER



$V = 192 \times (2.9 - .4) \times 1.6 - (1.0^2 \times .785 \times 1.6 \times 38)$

$= 720\ in^3$

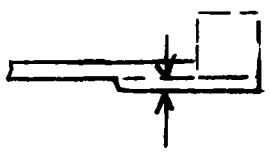
LOWER

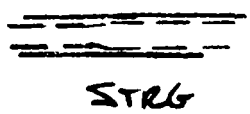
$V = 192 \times (3.0 - .4) \times 2.0 - (1.125^2 \times .785 \times 2.0 \times 38)$

$= 923\ in^3$

INBOARD BEEF-UP TO BASIC COVER SKIN & STRGS

UPPER





SKIN $4.8 \times .1 \times 192 = 92\ in^3$

STRINGER

$V = 38 \times 1.95 \times (.7 \times 1/2) \times 5 = 130\ in^3$

LOWER

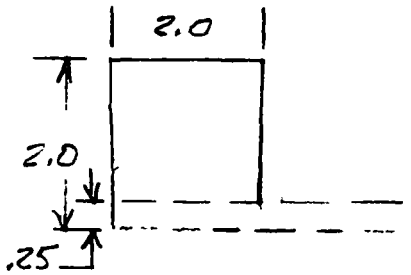
SKIN. $4.9 \times .10 \times 192 = 94\ in^3$

STRINGER

$V = 38 \times 1.95 \times (.7 \times \frac{1}{2}) \times 5 = 130\ in^3$

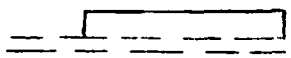
UPPER COVER

OUTBOARD ATTACH FLANGE



$V = 1.75 \times 2.0 \times 92 = 322 \text{ in}^3$

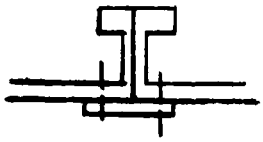
AFT SPAR ATTACH BEEF-UP



$V = 3.62 \times .30 \times 180 + 4.0 \times .125 \times 538$

$= 464 \text{ in}^3$

COVER SKIN SPLICE STRAPS REF 899A20D0599 SH 1 OF 8, 2 OF 8, 3 OF 8



UPPER. $\Sigma L = 2095$ IN

$V = 2095 \times .15 \times 2.25 = 707 \text{ in}^3$

LOWER: $\Sigma L = 2095$ IN

$V = 2095 \times .15 \times 2.25 = 707 \text{ in}^3$

SPLICE STRAP TO COVER SKIN ATTACHMENTS

HEAD & NUT:

$V = .26^2 \times .785 \times .32 = .017 \text{ in}^3$

ASSUME .8 IN SPACING

$\Sigma V_{\text{PER SURFACE}} = (2095 \div .8) \times .017 \times 2 = 89 \text{ in}^3$

SHANK

$V = .4 \times .185^2 \times .785 = .0107 \text{ in}^2$

$\Sigma V_{\text{PER SURFACE}} = (2095 \div .8) \times .0107 \times 2 = 56 \text{ in}^3$

SKIN SPLICE ATTACH

HEAD & NUT

$\Sigma V = (2095 \div .8) \times .017 \times 2 = 89 \text{ in}^3$

SHANK

$\Sigma V = (2095 \div .8) \times .0107 \times 2 = 56 \text{ in}^3$

LOWER COVER

VOLUME-WEIGHT CONVERSION SUMMARY

			TOTAL WING
STRINGERS			
STRINGERS	14518 X .101 =	1466 LB	2932
FILLETS	431 X .101 =	44	88
INBOARD BEEF-UP	130 X .101 =	13	26
TOTAL		1523	3046
SKIN			
SKIN	21410 X .101 =	2162	4324
INB'D BEEF-UP	94 X .101 =	9	18
INB'D ATTACH FLANGE	923 X .101 =	93	186
OUTB'D ATTACH FLANGE	230 X .101 =	23	46
AFT SPAR ATTACH BEEF-UP	464 X .101 =	47	94
		2334	4668
SKIN SPLICE STRAPS			
STRAPS	707 X .101 =	71	142
SKIN & SPLICE STRAP ATTACH			
SPLICE STRAP ATTACH	89 X .286 + 56 X (.286 - .101) =	36	72
SKIN SPLICE ATTACH	89 X .286 + 56 X (.286 - .101) =	36	72
TOTAL		143	286

LOWER COVER

SUMMARY

$$\Sigma V_{STRINGERS} = 1690+2130+102+130+1560+1958+43+63+1582+2350+179+236+447+877+18+36+412+666+13+26$$

$$= 14518\ in^3$$

$$\Sigma V_{SKIN} = 4879+4854+7404+3402+871$$

$$= 21410\ in^3$$

$$\Sigma V_{FILLETS} = 431\ in^3$$

$$\Sigma V_{\substack{INBOARD \\ STRINGER \\ BEEF-UP}} = 130\ in^3$$

$$\Sigma V_{\substack{INBOARD \\ SKIN \\ BEEF-UP}} = 94\ in^3$$

$$\Sigma V_{\substack{INBOARD \\ ATTACH \\ FLANGE}} = 923\ in^3$$

$$\Sigma V_{\substack{AFT\ SPAR \\ ATTACH \\ BEEF\ UP}} = 464\ in^3$$

$$\Sigma V_{\substack{OUTBOARD \\ ATTACH\ FLANGE}} = 230\ in^3$$

LOWER COVER STRINGERS
ROOT TO RIB NO. 1

REF STRESS INPUT, 899A2010 509 SHT 1 OF 8, 3 OF 8

$L_{AVG} = 103$ in

$w_0 = 1.25$ $\quad t_{F_0} = .4$

$w_1 = 1.25$ $\quad t_{F_1} = .35$

$w_m = 1.25$ $\quad t_{F_m} = .375$

$t_{w_0} = .30$ $\quad t_{s_0} = .30$

$t_{w_1} = .275$ $\quad t_{s_1} = .275$

$t_{w_m} = .2875$ $\quad t_{s_m} = .2875$

$H_0 = 2.85$, $h_0 = 2.15$

$H_1 = 2.60$, $h_1 = 1.975$

$H_m = 2.725$, $h_m = 2.05$

$$V_{①} = 35 \times \frac{103}{6} \times [1.25 \times .4 + 1.25 \times .35 + 1.25 \times .375 \times 4] = 1690 \text{ in}^3$$

$$V_2 = 35 \times \frac{103}{6} \times [.30 \times 2.15 + .275 \times 1.975 + .2875 \times 2.05 \times 4] = 2130 \text{ in}^3$$

VARIABLE LENGTH STRINGERS

$$V_{①} = \frac{110}{6}[1.25 \times .4 + 1.25 \times .36 + 4 \times 1.25 \times .38]$$
$$+ \frac{65}{6}[1.25 \times .4 + 1.25 \times .375 + 1.25 \times 4 \times .387]$$
$$+ \frac{38}{6}[1.25 \times .4 + 1.25 \times .39 + 1.25 \times .395 \times 4] = 102 \text{ in}^3$$

$$V_{②} = \frac{110}{6}(2.15 \times .30 + 1.98 \times .28 + 4 \times .29 \times 2.07)$$
$$+ \frac{65}{6}(2.15 \times .30 + 2.06 \times .287 + 2.1 \times .293 \times 4)$$
$$+ \frac{38}{6}(2.15 \times .30 + 2.1 \times .29 + 2.125 \times .295 \times 4) = 130 \text{ in}^3$$

DEN 066037 (3-57)

LOWER COVER STRINGERS

RIB No. 1 TO RIB No. 2

$W_0 = 1.25$ $\quad t_{F_0} = .35$

$W_1 = 1.25$ $\quad t_{F_1} = .30$

$W_m = 1.25$ $\quad t_{F_m} = .325$

$t_{W_0} = .275$ $\quad t_{S_0} = .275$

$t_{W_1} = .250$ $\quad t_{S_1} = .250$

$t_{W_m} = .2625$ $\quad t_{S_m} = .2625$

$H_0 = 2.60$) $\quad h_0 = 2.15$

$H_1 = 2.40$) $\quad h_1 = 1.85$

$H_m = 2.50$) $\quad h_m = 1.91$

FULL SECTION LENGTH = 120 in

$$V_① = 32 \times \frac{120}{6} \times [1.25 \times .35 + 1.25 \times .30 + 1.25 \times .325 \times 4] = 1560 \text{ in}^3$$

$$V_② = 32 \times \frac{120}{6} \times [.275 \times 2.15 + .250 \times 1.85 + .2625 \times 4 \times 1.91] = 1958 \text{ in}^3$$

LOWER COVER STRINGERS (CONT)

VARIABLE LENGTH RIBS NO 1 TO NO 2 (CONT)

L	W_1	t_{w_1}	t_{F_1}	t_{s_1}	H_1	h_1
75	1.25	.26	.325	.26	2.5	1.915
38	1.25	.27	.34	.27	2.58	2.01

$$V_{①} = \frac{75}{6}[1.25 \times .35 + 1.25 \times .325 + 1.25 \times .3375 \times 4] + \frac{38}{6}[1.25 \times .35 + 1.25 \times .34 + 1.25 \times .345 \times 4]$$
$$= 43 \text{ in}^3$$

$$V_{②} = \frac{75}{6}[1.915 \times .26 + 2.15 \times .275 + .2675 \times 4 \times 2.02] + \frac{38}{6}[2.15 \times .275 + 2.01 \times .27 + 4 \times .2725 \times 2.08]$$
$$= 63 \text{ in}^3$$

RIB NO. 2 TO RIB NO. 4

FULL SECTION LENGTH = 234 in

$W_0 = 1.25$ in, $t_{F_0} = .30$ in.
$W_1 = .80$ in., $t_{F_1} = .20$
$W_m = 1.025$, $t_{F_m} = .25$
$t_{w_0} = .25$, $t_{s_0} = .25$
$t_{w_1} = .20$, $t_{s_1} = .225$
$t_{w_m} = .225$, $t_{s_m} = .2375$
$H_0 = 2.40$, $h_0 = 1.85$
$H_1 = 2.00$ $h_1 = 1.575$
$H_m = 2.20$ $h_m = 1.75$ in.

LOWER COVER STRINGERS (CONT.)
RIB No. 2 TO RIB No. 4 (CONT)

$V_{①} = 26 \times \frac{234}{6} \times [1.25 \times .30 + .80 \times .20 + 1.025 \times .25 \times 4] = 1582 in^3$

$V_{②} = 26 \times \frac{234}{6} \times [.25 \times 1.85 + .20 \times 1.575 + .225 \times 1.71 \times 4] = 2350 in^3$

VARIABLE LENGTH STRGS No. 2 TO No. 4

L	W_1	t_{w_1}	t_{F_1}	t_{S_1}	H_1	h_1
200	.89	.205	.22	.202	2.05	1.628
150	.98	.215	.24	.207	2.15	1.703
112	1.06	.225	.25	.212	2.22	1.758
78	1.14	235	.26	.217	2.30	1.823
38	1.20	245	.28	.220	2.35	1.85

$V_{③} = \frac{200}{6}[1.25 \times .3 + .89 \times .22 + 4 \times .26 \times 1.07]$
$+ \frac{150}{6}[1.25 \times .3 + .98 \times .24 + 4 \times .27 \times 1.11]$
$+ \frac{112}{6}[1.25 \times .3 + 1.06 \times .25 + 4 \times .275 \times 1.15]$
$+ \frac{78}{6}[1.25 \times .3 + 1.14 \times .26 + 4 \times .28 \times 1.19]$
$+ \frac{38}{6}[1.25 \times .3 + 1.20 \times .28 + 4 \times .29 \times 1.22] = 179 in^3$

LOWER COVER STRINGERS (CONT)

VARIABLE STRINGERS RIB NO 2 TO NO. 9

$$V_2 = \frac{200}{6}[1.85 \times .25 + 1.628 \times .205 + 4 \times .215 \times 1.739]$$
$$+ \frac{150}{6}[1.85 \times .25 + 1.703 \times .215 + 4 \times .220 \times 1.78]$$
$$+ \frac{112}{6}[1.85 \times .25 + 1.758 \times .225 + 4 \times .2375 \times 1.809]$$
$$+ \frac{78}{6}[1.85 \times .25 + 1.823 \times .235 + 4 \times .2425 \times 1.836]$$
$$+ \frac{38}{6}[1.85 \times .25 + 1.85 \times .245 + 4 \times 1.85 \times .2475]$$
$$= 236 \text{ in}^3$$

LOWER COVER STRINGERS

RIB No. 4 TO ACT. OUTB'D

FULL SECTION LENGTH = 135 in.

$W_0 = .80$, $t_{F_0} = .20$, $t_{w_0} = .20$
$W_1 = .80$, $t_{F_1} = .16$, $t_{w_1} = .18$
$W_m = .80$, $t_{F_m} = .18$, $t_{w_m} = .19$

$t_{s_0} = .225$, $H_0 = 2.00$, $h_0 = 1.575$
$t_{s_1} = .225$, $H_1 = 1.79$, $h_1 = 1.395$
$t_{s_m} = .225$, $H_m = 1.89$, $h_m = 1.485$

$$V_{①} = 23 \times \frac{135}{6} \times (.80 \times .20 + .80 \times .16 + 4 \times .80 \times .18)$$
$$= 447 \text{ in}^3$$

$$V_{②} = 23 \times \frac{135}{6} \times (.20 \times 1.575 + .18 \times 1.395 + 4 \times .19 \times 1.485)$$
$$= 877 \text{ in}^3$$

VARIABLE LENGTH STRINGERS – RIB 4 TO OUTB'D ACT

$$V_{①} = \frac{80}{6} \times (.80 \times .20 + .80 \times .17 + 4 \times .80 \times .185)$$
$$+ \frac{40}{6} \times (.80 \times .20 + .80 \times .185 + 4 \times .80 \times .192) = 18 \text{ in}^3$$

$$V_{②} = \frac{80}{6} \times (.20 \times 1.575 + 1.485 \times .19 + 4 \times .195 \times 1.53)$$
$$+ \frac{40}{6} \times (.20 \times 1.575 + .195 \times 1.52 + 4 \times .1975 \times 1.545) = 36 \text{ in}^3$$

ACT. OUTB'D TO TIP

FULL SECTION $L = 143$ in.

$W_0 = .80$, $t_{F_0} = .16$, $H_0 = 1.78$
$W_1 = W_m = .80$, $t_{F_1} = .20$, $H_1 = 1.50$
$t_{w_0} = .20$, $t_{F_m} = .180$, $H_m = 1.64$
$t_{w_1} = .18$, $t_{s_0} = .225$, $h_0 = 1.395$
$t_{w_m} = .19$, $t_{s_1} = .250$, $h_1 = 1.05$
$t_{s_m} = .2375$, $h_m = 1.223$

LOWER COVER STRINGERS (CONT)

AFT OUTB'D TO TIP (CONT)

$$V_{①} = 20 \times \frac{143}{6} \times (.80 \times .16 + .80 \times .20 + 4 \times .80 \times .18) = 412 in^3$$

$$V_{②} = 20 \times \frac{143}{6} \times (.20 \times 1.395 + .18 \times 1.05 + .19 \times 4 \times 1.223) = 666 in^3$$

VARIABLE LENGTH STRINGERS

$$V_{①} = \frac{70}{6}(.80 \times .16 + .80 \times .17 + 4 \times .80 \times .165)$$
$$+ \frac{30}{6}(.80 \times .16 + .80 \times .165 + 4 \times .80 \times .1675) = 13 in^3$$

$$V_{②} = \frac{70}{6} \times (1.395 \times .20 + 1.223 \times .19 + 4 \times 1.30 \times .195)$$
$$+ \frac{30}{6} \times (1.395 \times .20 + .195 \times 1.30 + 4 \times 1.35 \times .1925) = 26 in^3$$

REF : STRESS INPUT, [illegible] 599-1 OF 8 3 OF 8

LOWER COVER SKIN — ROOT TO NO 1 RIB

$t_{s_0} = .290$, c_0 168

$t_{s_1} = .275$, $c_1 = 160$

$t_{sm} = .282$, $c_m = 169$

$V = \frac{60}{6}[.29 \times 168 + .275 \times 160 + 4 \times .282 \times 169]$

$+ 190 \times 75 \times \frac{1}{2} \times .295 = 4879\ in^3$

RIB NO. 1 TO RIB NO. 2

$t_{s_0} = .275$ $\quad c_0 = 160$

$t_{s_1} = .250$ $\quad c_1 = 146$

$t_{sm} = .265$ $\quad c_m = 153$

$V = \frac{120}{6}[.275 \times 160 + .25 \times 146 + 4 \times .265 \times 153]$

$= 4854\ in^3$

RIB NO 2 TO RIB NO. 4

$t_{s_0} = .25$ $\quad c_0 = 146$

$t_{s_1} = .225$ $\quad c_1 = 120$

$t_{sm} = .2375$ $\quad c_m = 133$

$V = \frac{234}{6}[.25 \times 146 + .225 \times 120 + 4 \times .2375 \times 133]$

$= 7404\ in^3$

LOWER COVER SKIN (CONT)

RIB NO 4 TO OUTB'D ACT.

$t_{s_0} = .225$ $\quad C_0 = 120$

$t_{s_1} = .225$ $\quad C_1 = 104$

$t_{s_m} = .225$ $\quad C_m = 112$

$$V = \frac{135}{6}\left[.225 \times 120 + .225 \times 104 + .225 \times 112 \times 4\right]$$

$$= 3402\ in^3$$

OUTB'D ACT. TO TIP

$t_{s_0} = .225$ $\quad C_0 = 104$

$t_{s_1} = .250$ $\quad C_1 = 85$

$t_{s_m} = .2375$ $\quad C_m = 94$

$$V = \frac{39}{6}\left[.225 \times 104 + .25 \times 85 + .2375 \times 94 \times 4\right]$$

$$= 871\ in^3$$

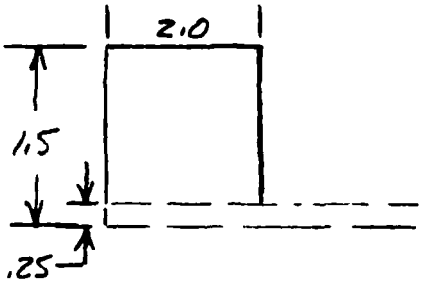
STRINGER FILLETS

$\Sigma L = 20650$ in.

$$V = 20650 \times .156^2 \times .2146 \times 4 = 431\ in^3$$

LOWER COVER

OUTBOARD ATTACH FLANGE



$V = 1.25 \times 2.0 \times 92 = 230 \text{ in}^3$

AFT SPAR ATTACH BEEF-UP

$V = 3.62 \times .30 \times 180 + 4.0 \times .125 \times 538$
$= 464 \text{ in}^3$

FORWARD SPAR REF. STRESS INPUT, 899A2010599 1 OF 8
2 OF 8, 3 OF 8, 4 OF 8

VOLUME WEIGHT CONVERSION SUMMARY

WEB	.101 x 3977 =	402 LB
WEB STIFFENERS	.101 x 1500 =	152
UPPER CAP	.101 x 778 =	79
LOWER CAP	.101 x 778 =	79
		712 LB.
ATTACH., SPLICES USE 10%		71
		7

FORWARD SPAR

WEB

ROOT TO BULKH'D NO. 2

$t = .15$ in.

$L = 270$ in., $h_{AVG} = 46.4$ in

$V = .15 \times 270 \times 46.4 = 1879\ in^3$

BULKH'D NO. 2 TO BULKH'D NO 5

$t = .120$ in.

$L = 387$ in. $h_{AVG} = 37.6$ in

$V = .120 \times 387 \times 37.6 = 1746\ in^3$

BULKH'D NO. 5 TO TIP

$t = .100$ in.,

$L = 110$ in., $h_{AVG} = 32$ in

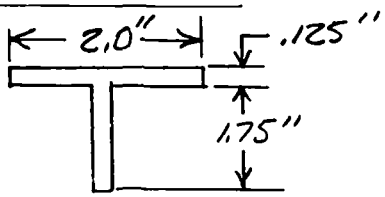
$V = .100 \times 110 \times 32 = 352\ in^3$

TOTAL WEB

$\Sigma V = 1879 + 1746 + 352 = 3977\ in^3$

FORWARD SPAR

WEB STIFFENERS

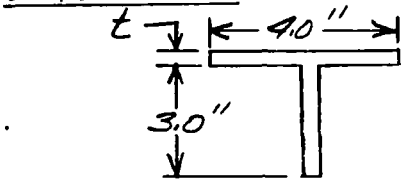


$A = (2.0 + 1.75) \times .125 = .470\ in^2$
$\approx .50\ in.^2$

10 in. SPACING, $h_{AVG} = (50+28) \div 2 = 39$ in.

$V = \frac{770}{10} \times 39 \times .50 = 1500\ in^3$

UPPER CAP



ROOT TO BULKH'D 2
$A = 7.0 \times .160 = 1.12\ in^2$

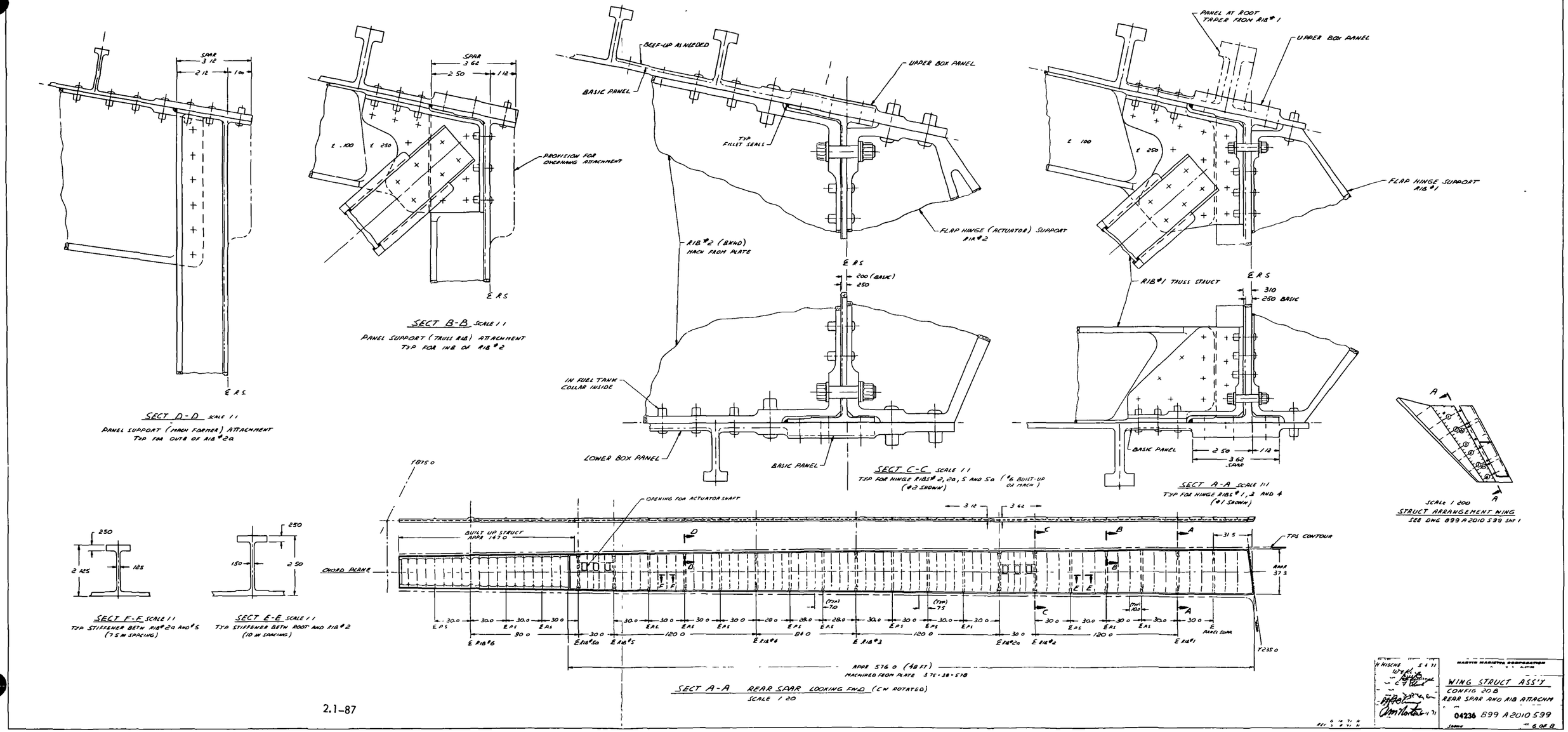
BULKH'D No. 2 TO No. 5
$A = 7.0 \times .140 = .98$

BULKH'D No 5 TO TIP
$A = .125 \times 7.0 = .875\ in^2$

$V = 270 \times 1.12 + 387 \times .98 + 110 \times .875$
$= 778\ in^3$

LOWER CAP

USE SAME SIZES AS UPPER CAP
$V = 778\ in^3$


SPAR 3.12
2.12
1.00
℄ R.S.
SECT D-D SCALE 1:1
PANEL SUPPORT (MACH FORMER) ATTACHMENT
TYP FOR OUTB OF RIB #2a
SPAR 3.62
2.50
1.12
℄ .100
℄ 250
PROVISION FOR OVERHANG ATTACHMENT
℄ R.S.
SECT B-B SCALE 1:1
PANEL SUPPORT (TRUSS RIB) ATTACHMENT
TYP FOR INB OF RIB #2
BEEF-UP AS NEEDED
BASIC PANEL
UPPER BOX PANEL
TYP FILLET SEALS
FLAP HINGE (ACTUATOR) SUPPORT RIB #2
RIB #2 (BKND) MACH FROM PLATE
℄ R.S.
200 (BASIC)
250
IN FUEL TANK COLLAR INSIDE
LOWER BOX PANEL
BASIC PANEL
SECT C-C SCALE 1:1
TYP FOR HINGE RIBS # 2, 2a, 5 AND 5a (#6 BUILT-UP OR MACH)
(#2 SHOWN)
PANEL AT ROOT TAPER FROM RIB # 1
UPPER BOX PANEL
℄ .100
℄ 250
FLAP HINGE SUPPORT RIB #1
RIB #1 TRUSS STRUCT
℄ R.S.
310
250 BASIC
BASIC PANEL
2.50
1.12
3.62 SPAR
SECT A-A SCALE 1:1
TYP FOR HINGE RIBS # 1, 3 AND 4
(#1 SHOWN)
A
A
SCALE 1:200
STRUCT ARRANGEMENT WING
SEE DWG 899 A2010 599 SHT 1
250
2.125
125
SECT F-F SCALE 1:1
TYP STIFFENER BETW RIB #2a AND #5
(7.5 IN SPACING)
250
150
2.50
SECT E-E SCALE 1:1
TYP STIFFENER BETW ROOT AND RIB #2
(10 IN SPACING)
1875.0
OPENING FOR ACTUATOR SHAFT
BUILT UP STRUCT APPR 147.0
CHORD PLANE
3.12
3.62
31.5
TPS CONTOUR
APPR 37.3
(TYP) 7.0
(TYP) 7.5
(TYP) 10.0
30.0
℄ PS
℄ RIB #6
90.0
℄ RIB #5a
℄ RIB #5
120.0
℄ RIB #4
84.0
℄ RIB #3
120.0
℄ RIB #2a
℄ RIB #2
120.0
℄ RIB #1
℄ PANEL SUPR
Y235.0
APPR 576.0 (48 FT)
MACHINED FROM PLATE 3.75 - 38 - 578
SECT A-A REAR SPAR LOOKING FWD (CW ROTATED)
SCALE 1:20
H HISCHE 5 4 71
MARTIN MARIETTA CORPORATION
WING STRUCT ASS'Y
CONFIG 20 B
REAR SPAR AND RIB ATTACHM
04236 899 A2010 599
SHOWN
6 OF 8

AFT SPAR

VOLUME-WEIGHT SUMMARY

WEB	.101 x 4577	= 462 LB
WEB STIFFENERS	.101 x 771	= 179 LB
UPPER CAP	.101 x 375 =	38 LB
LOWER CAP	.101 x 375 =	38 LB
		717 LB
SPAR TO SKIN ATTACH. & SPLICES		71

AFT SPAR REF MMC DRG 899A20105 99

SHT 1 OF 8, 6 OF 8
STRESS INPUT

WEB

ROOT TO BULKHEAD No. 2

$$V = .25 \times 181.5 \times \frac{34+35.5}{2} = 1577 \text{ in}^3$$

BULKHEAD No. 2 TO HINGE RIB No. 5

$$V = .20 \times 354 \times \frac{34+29.5}{2} = 2248 \text{ in}^3$$

HINGE RIB No. 5 TO TIP

$$V = .15 \times 184 \times \frac{29.5+25}{2} = 752 \text{ in}^3$$

$$\Sigma V = 1577 + 2248 + 752 = 4577 \text{ in}^3$$

UPPER CAP

ROOT TO BLKHD No. 2

$$V = 213 \times (2.6 \times .2 + 1.16 \times .125) = 142 \text{ in}^3$$

BULKH'D NO 2 TO BULKH'D No. 5A

$$V = 360 \times 3.12 \times .15 = 168 \text{ in}^3$$

BULKH'D 5A TO TIP

$$V = 146 \times 2.6 \times .15 = 57 \text{ in}^3$$

FILLET

$$V = .156^2 \times .2146 \times 2 \times 719 = 8 \text{ in}^3$$

$$\Sigma V = 142 + 168 + 57 + 8 = 375 \text{ in}^3$$

AFT SPAR

LOWER CAP

USE S/A UPPER CAP

$V = 375\ in^3$

WEB STIFFENERS

ROOT TO BULKHEAD NO. 2

$A = .25 \times 1.25 + 2.05 \times .15 + 1.4 \times .02 + .156^2 \times .2146 \times 4 = .669\ in^2$

$\Sigma H = 3 \times 36 + 3 \times 35 + 3 \times 35 + 3 \times 34.5 + 6 \times 34 = 625\ in.$

$V = .669 \times 625 = 418\ in^3$

BULKH'D NO 2 TO BULKH'D NO 5

$A = .25 \times 1.0 + 1.7 \times .125 + + 1.1 \times .02 + .156^2 \times .2146 \times 9 = .505\ in^2$

$\Sigma H = 12 \times 33 + 12 \times 32 + 12 \times 31 + 12 \times 30 = 1512\ in$

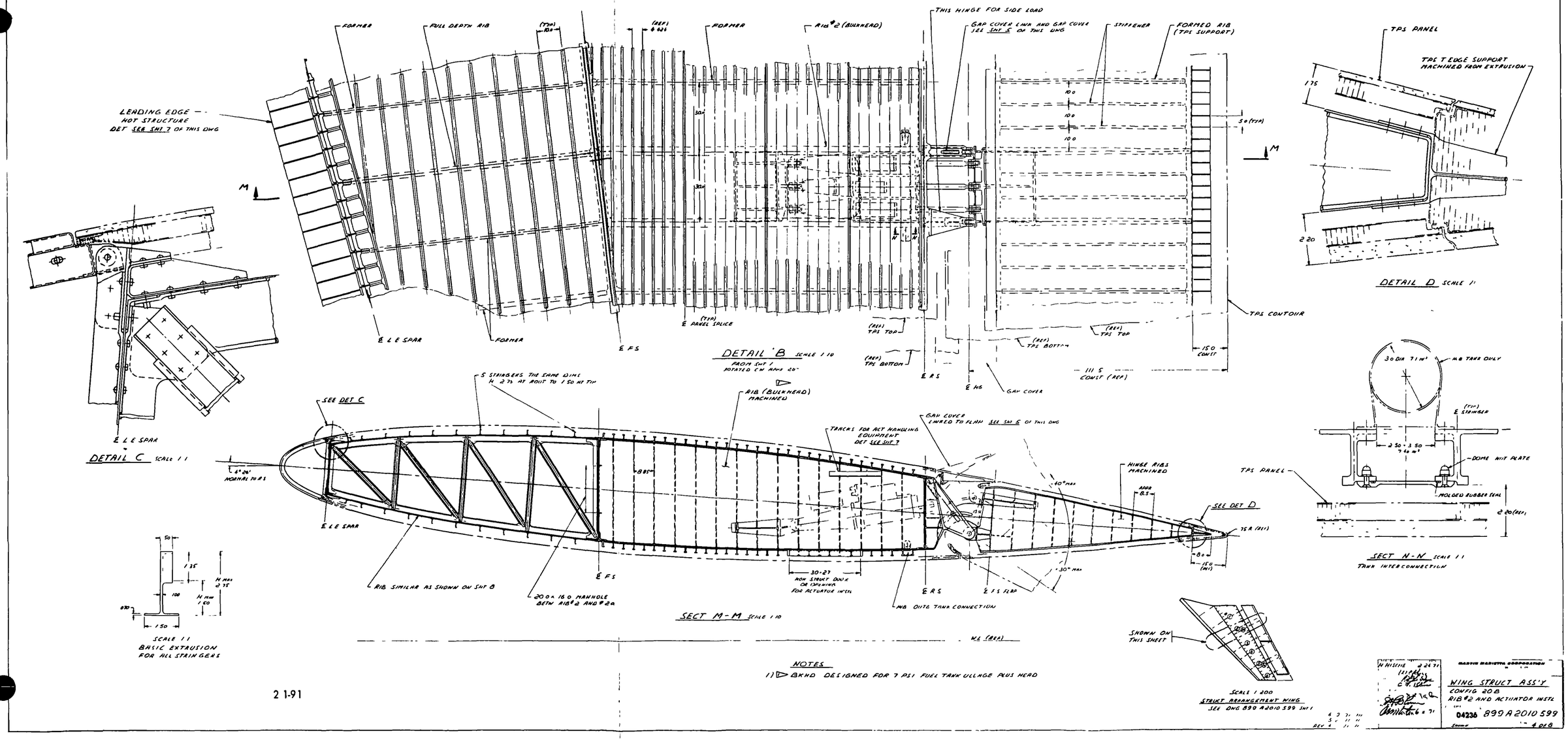
$V = 1512 \times .505 = 764\ in^3$

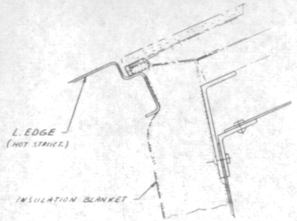
BULKH'D NO 5 TO TIP

$A \approx .50\ in^2$

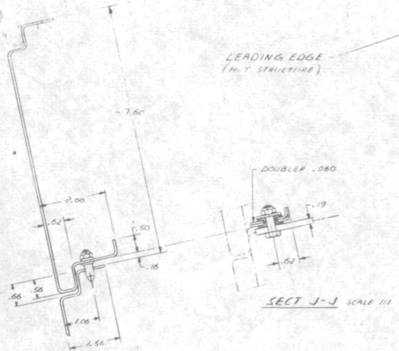
$\Sigma H = 13 \times 28 + 9 \times 25 = 589\ in.$

$\Sigma V = 418 + 764 + 589 = 1771\ in^3$


FORMER
FULL DEPTH RIB
FORMER
RIB #2 (BULKHEAD)
THIS HINGE FOR SIDE LOAD
GAP COVER LINK AND GAP COVER SEE SHT 5 OF THIS DWG
STIFFENER
FORMED RIB (TPS SUPPORT)
TPS PANEL
TPS T EDGE SUPPORT MACHINED FROM EXTRUSION
LEADING EDGE HOT STRUCTURE DET SEE SHT 7 OF THIS DWG
℄ L E SPAR
FORMER
℄ F S
℄ PANEL SPLICE
(REF) TPS TOP
(REF) TPS BOTTOM
℄ R S
℄ HG
GAP COVER
TPS CONTOUR
DETAIL B SCALE 1:10
FROM SHT 1 ROTATED CW APPX 20°
DETAIL D SCALE 1:1
DETAIL C SCALE 1:1
SEE DET C
5 STRINGERS THE SAME DIMS H 2.75 AT ROOT TO 1.50 AT TIP
RIB (BULKHEAD) MACHINED
TRACKS FOR ACT HANDLING EQUIPMENT DET SEE SHT 7
GAP COVER LINKED TO FLAP SEE SHT 5 OF THIS DWG
HINGE RIBS MACHINED
SEE DET D
TPS PANEL
MOLDED RUBBER SEAL
DOME NUT PLATE
SECT N-N SCALE 1:1
TANK INTERCONNECTION
RIB SIMILAR AS SHOWN ON SHT 8
20.0 x 16.0 MANHOLE BETW RIB #2 AND #2a
30-27 NON STRUCT DOOR OR OPENING FOR ACTUATOR INSTL
HB OUTG TANK CONNECTION
℄ F S FLAP
SECT M-M SCALE 1:10
SCALE 1:1
BASIC EXTRUSION FOR ALL STRINGERS
SHOWN ON THIS SHEET
SCALE 1:200
STRUCT ARRANGEMENT WING
SEE DWG 899 A2010 599 SHT 1
NOTES
1) BKHD DESIGNED FOR 7 PSI FUEL TANK ULLAGE PLUS HEAD
MARTIN MARIETTA CORPORATION
WING STRUCT ASS'Y
CONFIG 20B
RIB #2 AND ACTUATOR INSTL
04236 899 A 2010 599
4 of 8

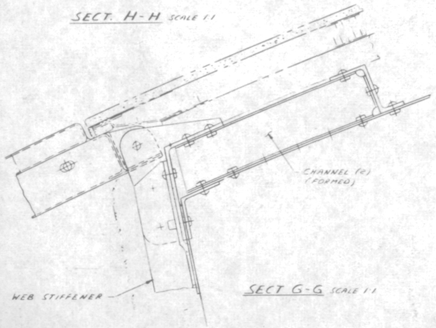


SECT K-K SCALE 1:1

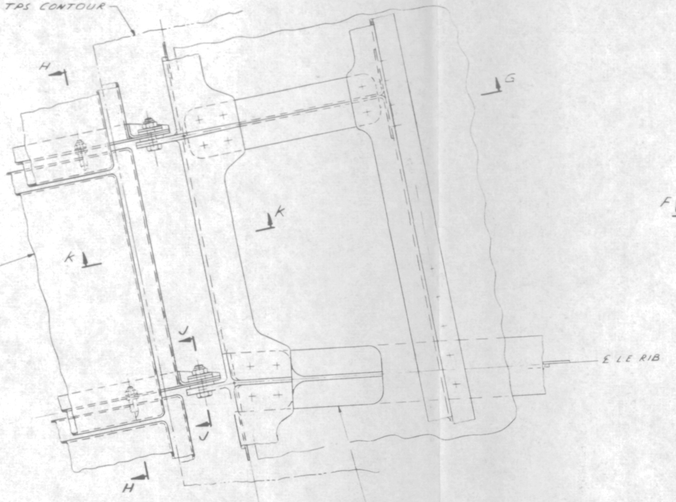


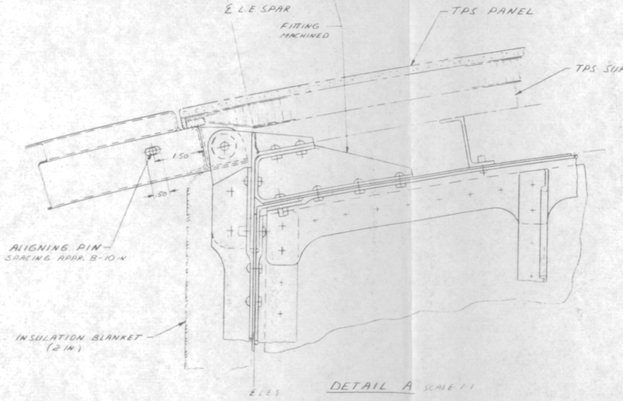
SECT J-J SCALE 1:1

SECT H-H SCALE 1:1

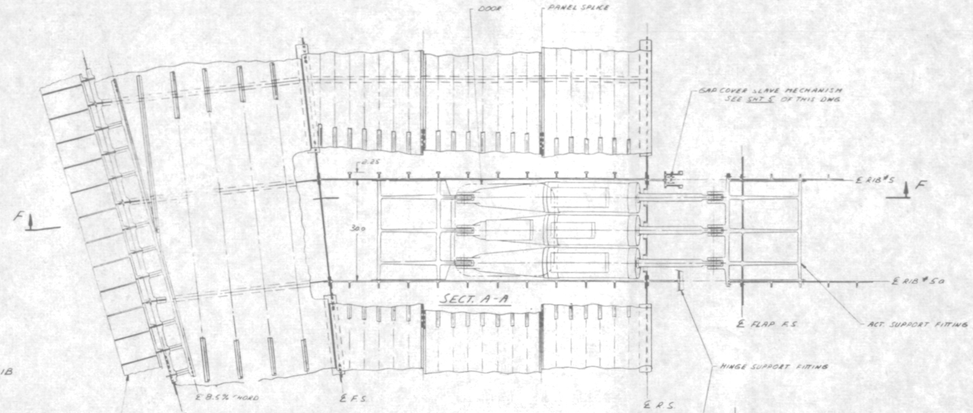


SECT G-G SCALE 1:1



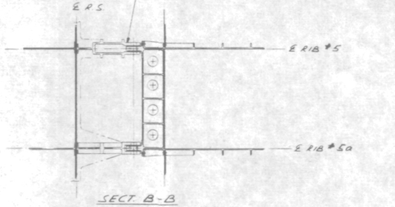


DETAIL A SCALE 1:1

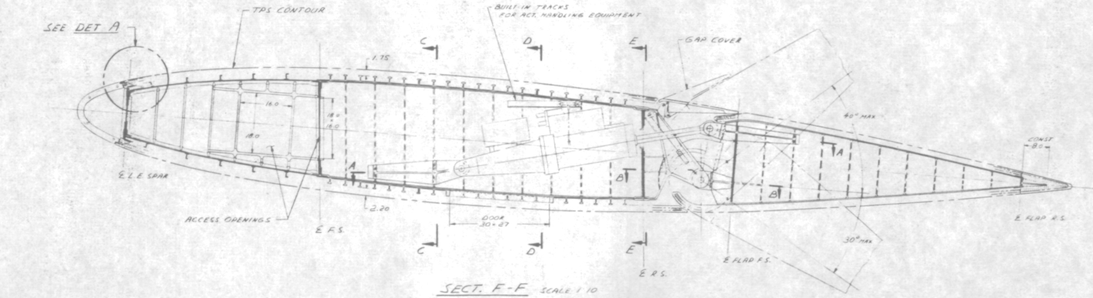


SECT A-A

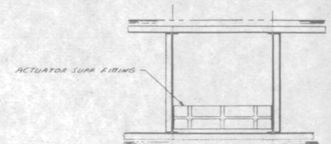
PLAN VIEW SCALE 1:10
(C.W. ROTATED)



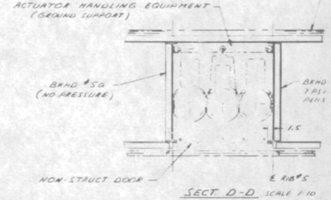
SECT B-B



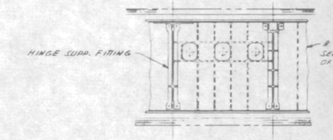
SECT F-F SCALE 1:10



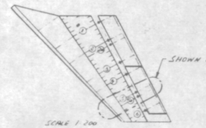
SECT C-C SCALE 1:10



SECT D-D SCALE 1:10



SECT E-E SCALE 1:10



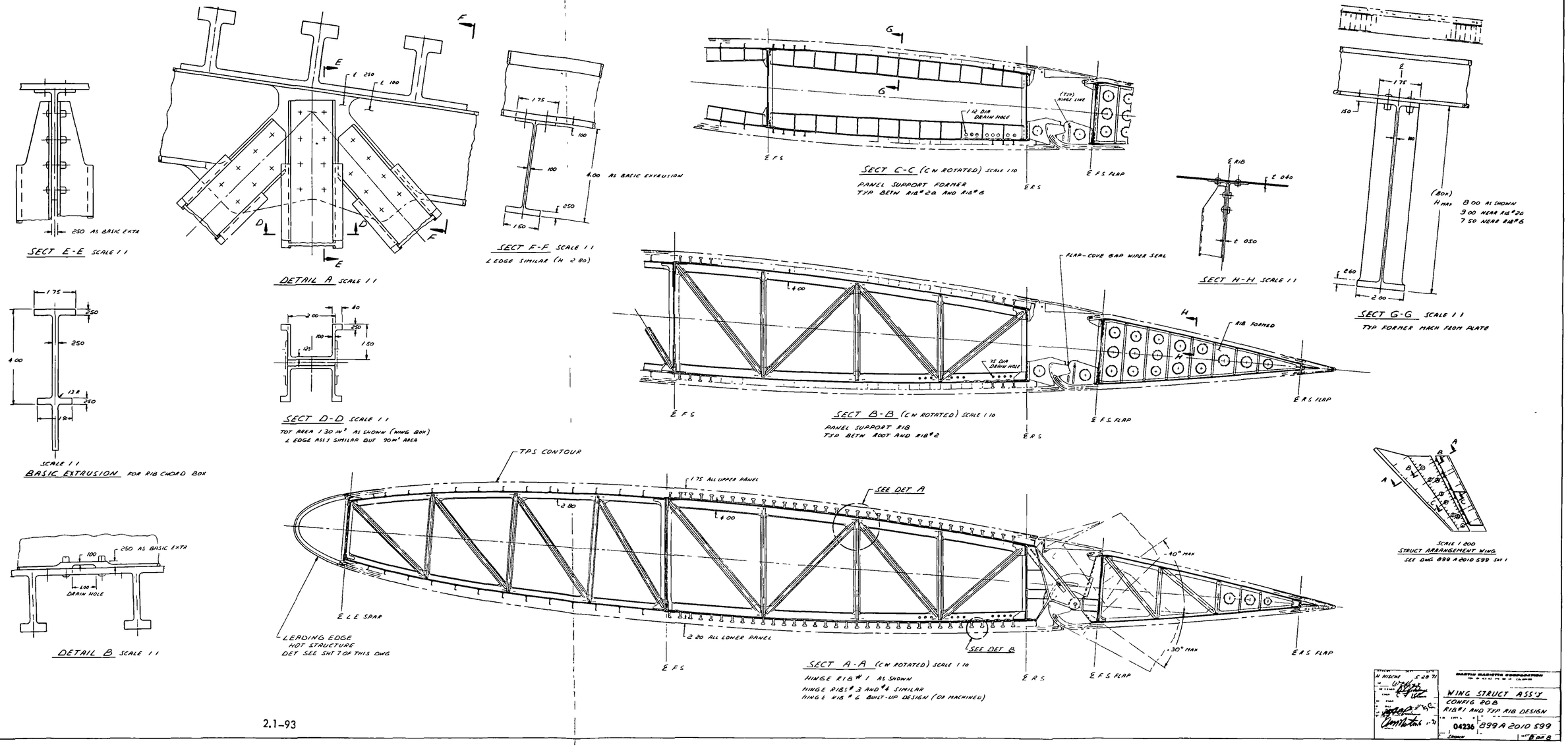
SCALE 1:200
STRUCT. ARRANGEMENT WING
SEE DWG 89PA10E599 SHT 1

DRAWN	H HITCHE	7-71
CHECKED		
ENGR APPROV.		
PROJ. ENGR		

MARTIN MARIETTA CORPORATION
DENVER, COLORADO

WING STRUCT ASS'Y
CONFIG 20B
RIB #5, ACT INCTL AND LEDGE

CONTR. NO. NAS8-26000
04236 89PA2010599
SHEET 7 OF 8


SECT E-E SCALE 1:1
250 AS BASIC EXTR
DETAIL A SCALE 1:1
SECT F-F SCALE 1:1
∠ EDGE SIMILAR (H 2.80)
4.00 AS BASIC EXTRUSION
SECT C-C (CW ROTATED) SCALE 1:10
PANEL SUPPORT FORMER
TYP BETW RIB#2A AND RIB#6
1.12 DIA DRAIN HOLE
(TYP) HINGE LINE
SECT H-H SCALE 1:1
SECT G-G SCALE 1:1
TYP FORMER MACH FROM PLATE
(BOX) H MAX 8.00 AS SHOWN
9.00 NEAR RIB#2A
7.50 NEAR RIB#6
SECT D-D SCALE 1:1
TOT AREA 1.30 IN² AS SHOWN (WING BOX)
∠ EDGE ASS'Y SIMILAR BUT 90 IN² AREA
SCALE 1:1
BASIC EXTRUSION FOR RIB CHORD BOX
FLAP-COVE GAP WIPER SEAL
RIB FORMED
.75 DIA DRAIN HOLE
SECT B-B (CW ROTATED) SCALE 1:10
PANEL SUPPORT RIB
TYP BETW ROOT AND RIB#2
TPS CONTOUR
1.75 ALL UPPER PANEL
SEE DET A
2.20 ALL LOWER PANEL
SEE DET B
LEADING EDGE
HOT STRUCTURE
DET SEE SHT 7 OF THIS DWG
SECT A-A (CW ROTATED) SCALE 1:10
HINGE RIB#1 AS SHOWN
HINGE RIBS#3 AND #4 SIMILAR
HINGE RIB#6 BUILT-UP DESIGN (OR MACHINED)
DETAIL B SCALE 1:1
250 AS BASIC EXTR
1.00 DRAIN HOLE
SCALE 1:200
STRUCT ARRANGEMENT WING
SEE DWG 899 A 2010 599 SHT 1
MARTIN MARIETTA CORPORATION
WING STRUCT ASS'Y
CONFIG 20B
RIB#1 AND TYP RIB DESIGN
04236 899 A 2010 599
SHOWN
8 OF 8

RIBS & FORMERS

VOLUME-WEIGHT CONVERSION SUMMARY

ROOT CLOSING RIB :	.101 x 3934 =	397 LB.
NO. 2 BULKHEAD:	.101 x 1389 =	140 LB
NO. 2A BULKHEAD:	.101 x 1389 =	140 LB
NO. 5. BULKHEAD:	.101 x 1008 =	102 LB
NO. 5A BULKHEAD:	.101 x 1008 =	102 LB
NO. 1 HINGE RIB:	.101 x 735 =	74 LB
NO. 3 HINGE RIB	.101 x 607 =	61 LB
NO. 4 HINGE RIB	.101 x 555 =	56 LB
NO. 6 HINGE RIB	.101 x 429 =	43 LB
TIP RIB	.101 x 414 =	42 LB. 1157 LB
FORMER 1	.101 x 324 =	33 LB
FORMER 2	.101 x 685 =	69 LB
FORMER 3	.101 x 749 =	76 LB
FORMER 4	.101 x 724 =	73 LB
FORMER 5	.101 x 700 =	71 LB
FORMER 6	.101 x 693 =	70 LB
FORMER 7	.101 x 678 =	68 LB
FORMERS OUTB'D OF BULKH'D 2A	.101 x 5008 =	506 LB 966 LB
RIB & FORMER TO SKIN ATTACH & SPLICES	.15 x 1983	309 LB

ROOT CLOSING RIB REF 899A2010599 SHT 1 OF 8
2 OF 8, 4 OF 8, 6 OF 8, 7 OF 8
8 OF 8

UPPER FLANGE

$$V = 192 \times 2.0 \times .6 - .5^2 \times .785 \times .6 \times 77 + .55 \times .35 \times 192 + 1.125 \times 1.2 \times 2 \times .35 \times \frac{192}{5}$$

$$= 295 \text{ in}^3$$

LOWER FLANGE

S/A UPPER FLANGE

$$V = 295 \text{ in}^3$$

WEB

AFT HALF:

$$A = 80 \times \frac{48.5+32}{2} = 3220 \text{ in}^2, \quad t_{AVG} = \frac{48.5}{80.5} \times .23 + \frac{32}{80.5} \times .365 = .2837$$

$$V = 3220 \times .2837 = 914 \text{ in}^3$$

FWD HALF:

$$A = 111 \times \frac{48.5+54}{2} = 5689 \text{ in}^2, \quad t_{AVG} = \frac{48.5}{102.5} \times .315 + \frac{54}{102.5} \times .235 = .2729$$

$$V = 5689 \times .2729 = 1552 \text{ in}^3$$

$$\Sigma V = 914 + 1552 = 2466 \text{ in}^3$$

ROOT CLOSING RIB (CONT)

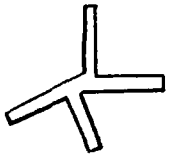
WEB STIFFENERS

$$\text{AREA} = 1.5 \times .3 + .25 \times 1.7 = .875 \text{ in}^2$$

$$L_{AVG} = 47 \text{ in}$$

$$V = 18 \times 47 \times .875 = 740 \text{ in}^3$$

FORWARD END CLOSING MEMBER



$$\Sigma \text{AREA} = 2.65 \text{ in}^2$$

$$V = 52 \times 2.65 = 138 \text{ in}^3$$

$$\Sigma V = 295 + 295 + 2466 + 740 + 138$$

$$\Sigma V = 3934 \text{ in}^3$$

No. 2 Bulkhead

Upper Cap

$L = 140$ in, $t = .25$
$W = 3.5$ in.

$V = 140 \times 3.5 \times .25 = 123 \text{ in}^3$

Lower Cap

$L = 140$ in, $t = .25$ in.
$W = 3.5$ in.

$V = 140 \times 3.5 \times .25 = 123 \text{ in}^3$

Shear Web

$t = .090$ in.

$A = 60 \times 43 + 82 \times 38 = 5696 \text{ in}^2$

$V = .090 \times 5696 = 513 \text{ in}^2$

No. 2 Bulkhead (Cont)

Shear Web Stiffeners

$V = 15 \times 2.0 \times 41.0 \times .125 = 154\ in^3$

End Plates

$V = 3.5 \times .25 \times (42+30) = 63\ in^3$

Fillet Material

$R = .156$ in

$V = .156^2 \times .2146 \times (15 \times 41 \times 2 + 2 \times 140 \times 2 + 2 \times 42 + 2 \times 30)$

$= 13\ in^3$

Add Actuator Provisions $400\ in^3$

Total Volume

$V = 123 + 123 + 513 + 154 + 63 + 13 + 400 = 1389\ in^3$

No. 2A Bulkhead

Use Same Sizes As Blkhd No. 2

$\Sigma = 1389\ in^3$

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BULKHEAD NO. 5

UPPER CAP

$L = 100$ in, $t = .25$

$W = 3.5$ in,

$V = 100 \times 3.5 \times .25 = 88 \text{ in}^3$

LOWER CAP

$L = 100$ in., $t = .25$ in.

$W = 3.5$ in.

$V = 100 \times 3.5 \times .25 = 88 \text{ in}^3$

SHEAR WEB

$t = .110$ in

$A = 100 \times 32 = 3200 \text{ in}^2$

$V = 3200 \times .110 = 352 \text{ in}^3$

No 5 Bulkhead (Cont)

Shear Web Stiffeners

$V = 12 \times 32.0 \times 2.0 \times .15 = 115 \text{ in}^3$

End Plates

$V = 3.5 \times .25 \times (33+30) = 55 \text{ in}^3$

Fillet Material

$V \approx 10 \text{ in}^3$

Actuator Exclusion $V = 300 \text{ in}^3$

Total Bulkhead Vol.

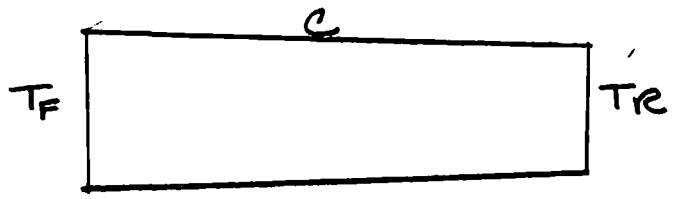
$\Sigma V = 88 + 88 + 352 + 115 + 55 + 10 + 300 = 1008 \text{ in}^3$

No. 5A Bulkhead

Use Same Sizes As No. 5 Bulkhd

$\Sigma V = 1008 \text{ in}^3$

RIBS (CONT)



$$\frac{T_{FR} - T_{FT}}{b_F} = \frac{62-30}{780} = .041$$

$$\frac{T_{RR} - T_{RT}}{b_R} = \frac{42-30}{736} = .0163$$

RIB	FWD SPAN	T_F	AFT SPAN	T_R	LESS TPS T_{FNET}	LESS TPS T_{RNET}
NO 1,	151	56	61	41	52	37
NO.2	271	51	181	39	47	35
NO.2A	301	50	211	39	46	35
NO.3	422	45	332	37	41	33
NO.4	507	41	414	35	37	31
NO.5	628	36	534	33	32	29
NO 5A	658	35	564	33	31	29
NO.6	748	30	653	33	26	27
FORMERS	32	61			57	
	62	59			55	
	91	58	5	42	54	38
	121	57	33	41	53	37
	180	55	92	41	51	37
	211	54	122	40	50	36
	241	52	152	40	48	36

RIBS & FORMERS

$\frac{2.85-1.5}{780} = .0017$, $\frac{2.85-1.5}{736} = .0018$

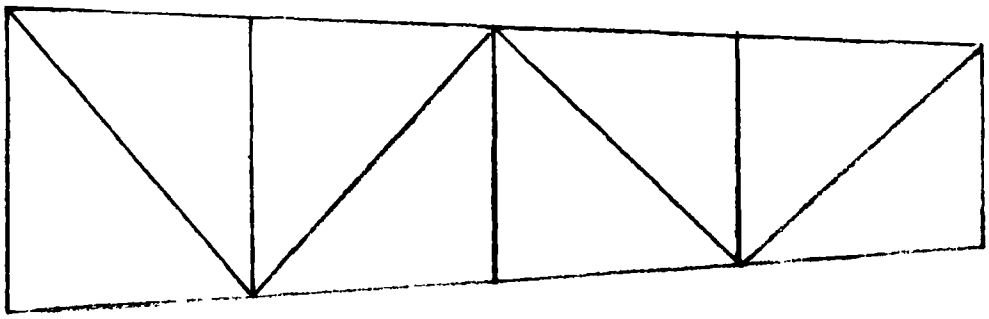
RIB	t_{COVER}	T_{FNET}	T_{RNET}
No 1	2.59	46.8	31.8
No 2	2.39	42.2	30.2
No 2A	2.34	41.5	30.3
No 3	2.13	36.7	28.7
No 4	1.99	33.0	27.0
No 5	1.79	33.4	30.4
No 5A	1.73	27.5	25.5
No 6	1.58	22.8	23.8
FORMERS	2.80	51.4	51.0
	2.75	49.5	51.0
	2.70	48.6	32.6
	2.65	47.7	31.7
	2.54	45.9	31.9
	2.49	45.0	31.0
	2.44	43.1	31.1

RIBS & FORMERS

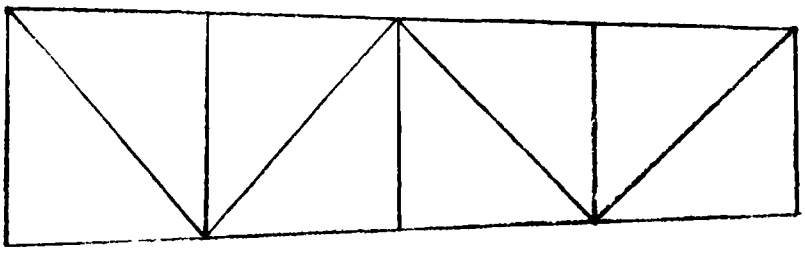
SKETCHES TO OBTAIN PROPER MEMBER LENGTHS

SCALE: 1" = 30"

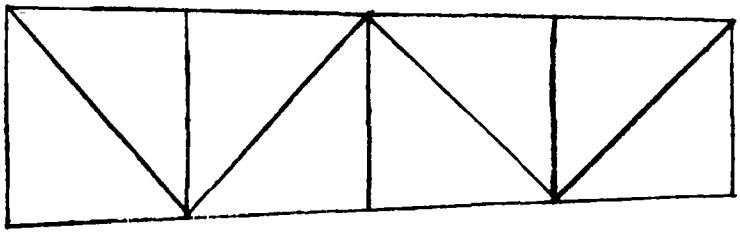
RIB NO. 1



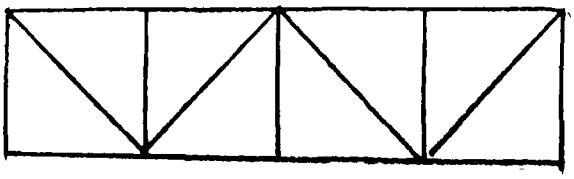
RIB NO 3



RIB NO 4



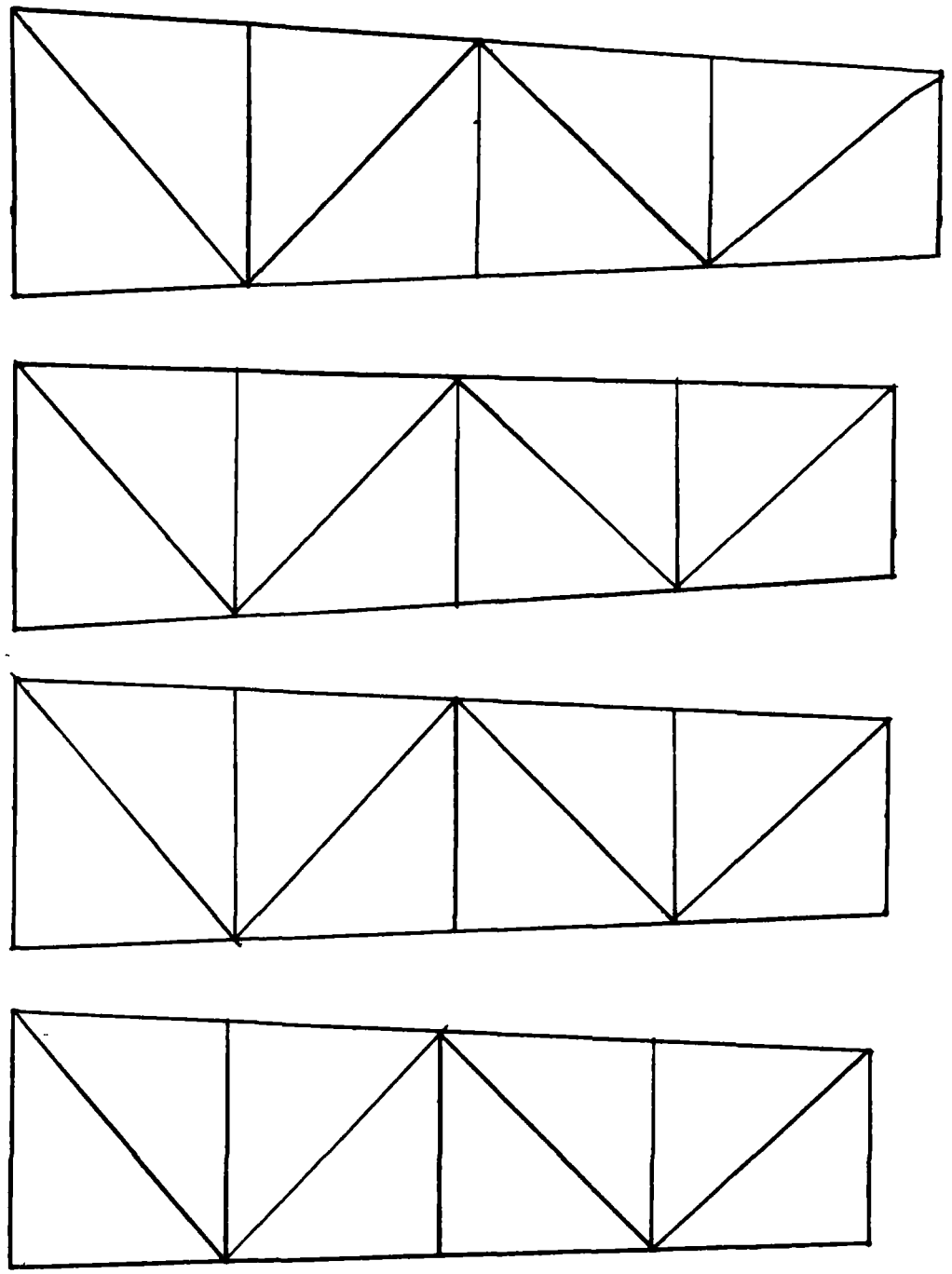
RIB NO 6



RIBS & FORMERS

FORMERS

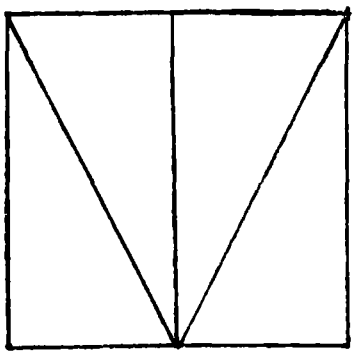
MEMBER LENGTH SKETCHES

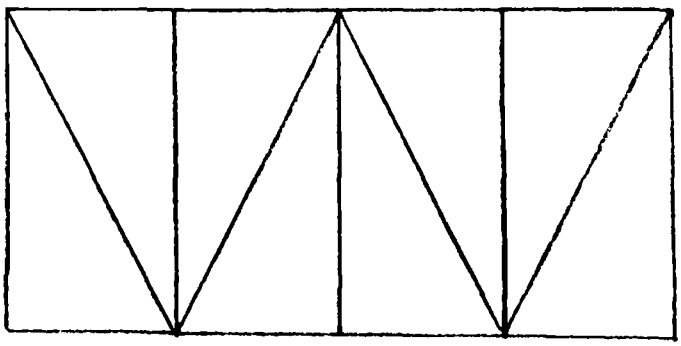


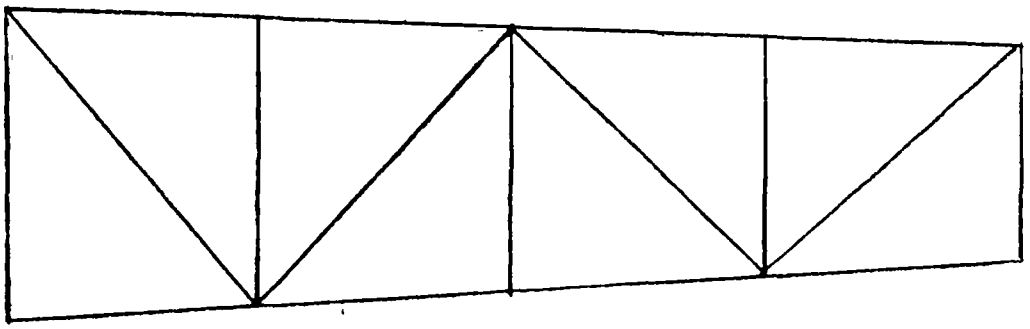
RIBS & FORMERS

SKETCHES TO OBTAIN PROPER MEMBER LENGTHS

FORMERS (IN ORDER FROM INB'D TO OUTB'D
SCALE 1"=30"

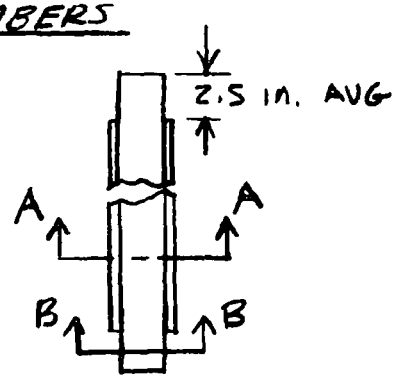




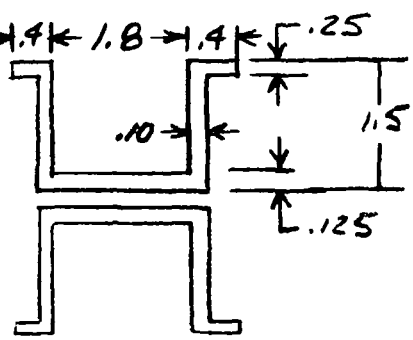


RIBS & FORMERS

TRUSS MEMBERS



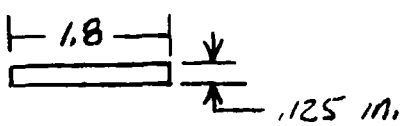
SECTION A-A



$$A_1 = 2(1.8 \times .125 + .3 \times 2 \times .25 + 2 \times .10 \times 1.5)$$

$$A_1 = 1.35 \text{ in}^2$$

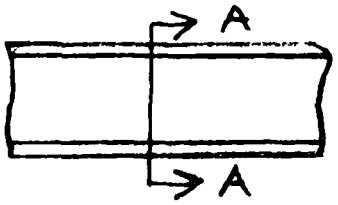
SECTION B-B



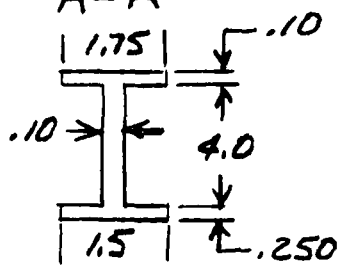
$$A_2 = (1.8 \times .125) \times 2 = .45 \text{ in}^2$$

RIBS & FORMERS

UPPER & LOWER CAPS



SECTION A-A



$$A = (1.5 \times .25 + 1.75 \times .10 + 3.65 \times .10)$$

$$A = .915 \text{ in}^2$$

HINGE RIBS REF. 899A2010617, 899A2010616

HINGE RIB NO. 1

TRUSS TYPE

UPPER CAP

$A = .915\ in^2$

$V = 154 \times .915 = 141\ in^3$

LOWER CAP

USE SAME SECTION AS UPPER CAP

$V = 154 \times .915 = 141\ in^3$

VERTICAL TRUSS MEMBERS

$A_1 = 1.35\ in^2$

$A_2 = .225\ in^2$

$V = (1.35)(43-5+39-5+35-5) + (.45)(5+5+5) = 144\ in^3$

DIAGONAL TRUSS MEMBERS

AREA S/A VERTICALS

$V = (1.35)(57-5+54-5+51-5+49-5) + (.45)(5+5+5+5) = 267\ in^3$

HINGE RIBS (CONT)

HINGE RIB NO. 1 (CONT)

ATTACHMENTS ~ DIAGONAL & VERTICAL MEMBERS TO CAPS

1/4" HI-SHEAR - HI-LOCK

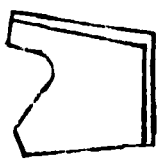
HEAD & NUT $.4^2 \times .785 \times .5 \times \frac{.286}{.1} = .18\ in^3$

SHANK $.25^2 \times .785 \times .5 \times (.286 - .10)\frac{1}{.1} = .05\ in^3$

$N \simeq 110$

$V = 110\ (.18 + .05) = 25\ in^3$

REAR JOINT FITTINGS



$V = 18.5 \times .125 + .18 \times 2.6 \times 1.5 + 2.2 \times .3 \times 1.5 = 4.\ in^3$

$V = 12.6 \times .125 + 6.2 \times 1.5 \times .18 + 2.5 \times .3 \times 1.5 = 4.4$

$\Sigma V = 2 \times 4 + 2 \times 4.4 = 17\ in^3$

HINGE RIB NO. 1 SUMMARY

UPPER CAP	141
LOWER CAP	141
VERTICALS	144
DIAGONALS	267
JOINTS	17
ATTACHMENTS	25
TOTAL	735 in^3

HINGE RIBS (CONT)

HINGE RIB NO. 3

UPPER CAP

$A = .915\ in^2$

$V = 125 \times .915 = 114\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = 125 \times .915 = 114\ in^3$

VERTICAL TRUSS MEMBERS

$A_1 = 1.35\ in^2,\quad A_2 = .225\ in^2$

$V = (1.35)(35-5+33-5+31-5) + (.45)(5+5+5) = 120\ in^3$

DIAGONAL TRUSS MEMBERS

$A_1 = 1.35$

$V = (1.35)(46-5+44-5+43-5+41-5) + (.45)(5+5+5+5) = 217\ in^3$

HINGE RIBS (CONT)
HINGE RIB NO. 3 (CONT)

CAP-EDGE MEMBER JOINTS
S/A HINGE RIB NO. 1
$V = 17\ in^3$

ATTACHMENTS ~ CAPS, VERTICAL & DIAGONAL MEMBERS
S/A HINGE RIB NO. 1
$V = 25\ in^3$

HINGE RIB NO. 3 SUMMARY

UPPER CAP	114
LOWER CAP	114
VERTICALS	120
DIAGONALS	217
JOINTS	17
ATTACHMENTS	25
TOTAL	$607\ in^3$

HINGE RIBS (CONT)

HINGE RIB NO. 4

UPPER CAP

$A = .915\ in^2$

$V = 115 \times .915 = 105\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = 115 \times .915 = 105\ in^3$

VERTICAL TRUSS MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(32-5+29-5+29-5) + (.45)(5+5+5) = 108\ in^3$

DIAGONAL TRUSS MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(42-5+40-5+39-5+37-5) + (.45)(5+5+5+5) = 195\ in^3$

HINGE RIBS (CONT)
HINGE RIB NO. 4 (CONT.)

CAP - EDGE MEMBER JOINTS

$V = 17\ in^3$

ATTACHMENTS - CAPS, VERTICAL & DIAGONAL MEMBERS

S/A HINGE RIB NO 1

$V = 25\ in^3$

HINGE RIB NO. 4 SUMMARY

UPPER CAP	105
LOWER CAP	105
VERTICALS	108
DIAGONALS	195
JOINTS	17
ATTACHMENTS	25
TOTAL	555 in^3

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NO. 6 HINGE RIB (BUILT-UP, ASSUME TRUSS CONSTRUCTION)

UPPER CAP

$A = .915\ in^2$

$V = 87 \times .915 = 80\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = 87 \times .915 = 80\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(23-5 + 23-5 + 23-5) + (.45)(5 + 5 + 5) = 80\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(30-5 + 30-5 + 31-5 + 31-5) + (.45)(5+5+5+5) = 147\ in^3$

ATTACHMENTS

S/A HINGE RIB NO. 1

$V = 25\ in^3$

CAP ~ EDGE MEMBER JOINTS

$V = 17\ in^3$

NO. 6 HINGE RIB SUMMARY

UPPER CAP	80
LOWER CAP	80
VERTICAL MEMBERS	80
DIAGONAL MEMBERS	147
JOINTS	17
ATTACHMENTS	25
TOTAL	429 in^3

RIBS & FORMERS

TIP CLOSING RIB

WEB $t = .090$

$V = 90 \times 26 \times .090 = 211 \text{ in}^3$

CAPS

$V = (95+95) \times 2.5 \times .25 = 119 \text{ in}^3$

WEB STIFFENERS

$V = 25 \times 1.5 \times .125 \times 12 = 56 \text{ in}^3$

END CAPS

$V = (23+22) \times 2.5 \times .25 = 28 \text{ in}^3$

TOTAL

$\Sigma V = 414 \text{ in}^3$

RIBS & FORMERS

FORMER 1 ~ USE SAME CONSTRUCTION AS TRUSS RIBS

UPPER CAP

$A = .915\ in^2$

$V = 53 \times .915 = 48\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = 53 \times .915 = 48\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(53-5) + (.45)(5) = 67\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(57-5+57-5) + (.45)(5+5) = 145\ in^3$

ATTACHMENTS

$N \approx 70$

$V = 70(.23) = 16\ in^3$

UPPER CAP	48
LOWER CAP	48
VERTICAL MEMBERS	67
DIAGONAL MEMBERS	145
ATTACH	16
TOTAL	324 in^3

RIBS & FORMERS

FORMER 2

UPPER CAP

$A = .915\ in^2$

$V = (.915)(105) = 96\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = (.915)(105) = 96\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(50-5+50-5+50-5) + (.45)(5+5+5) = 189\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(55-5+55-5+55-5+55-5) + (.45)(5+5+5+5) = 279\ in^3$

ATTACHMENTS

$V = 110(23) = 25\ in^3$

UPPER CAP	96
LOWER CAP	96
VERTICAL MEMBERS	189
DIAGONAL MEMBERS	279
ATTACH	25
TOTAL	685 in^3

RIBS & FORMERS

FORMER 3

UPPER CAP

$A = .915\ in^2$

$V = (.915)(160) = 146\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = (.915)(160) = 146\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45$

$V = (1.35)(45-5+40-5+36-5) + (.45)(5+5+5) = 150\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(60-5+58-5+54-5+50-5) + (.45)(5+5+5+5) = 282\ in^3$

ATTACHMENTS

$V = 110(.23) = 25\ in^3$

UPPER CAP	146
LOWER CAP	146
VERTICAL MEMBERS	150
DIAGONAL MEMBERS	282
ATTACH	25
TOTAL	749 in^3

RIBS & FORMERS

FORMER 4

UPPER CAP

$A = .915\ in^2$

$V = (.915)(157) = 144\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = (.915)(158) = 145\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(42-5+39-5+35-5) + (.45)(5+5+5) = 143\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(57-5+55-5+51-5+49-5) + (.45)(5+5+5+5) = 268\ in^3$

ATTACHMENTS

$V = 110(.23) = 25\ in^3$

UPPER CAP	144
LOWER CAP	145
VERTICAL MEMBERS	143
DIAGONAL MEMBERS	268
ATTACH	25
	724 in^3

RIBS & FORMERS

FORMER 5

UPPER CAP

$A = .915\ in^2$

$V = (.915)(147) = 135\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = (.915)(150) = 137\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(41-5+38-5+34-5) + (.45)(5+5+5) = 139\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(55-5+54-5+50-5+50-5) + (.45)(5+5+5+5) = 264\ in^3$

ATTACHMENTS

$V = 110(.23) = 25\ in^3$

UPPER CAP	135
LOWER CAP	137
VERTICAL MEMBERS	139
DIAGONAL MEMBERS	264
ATTACH.	25
TOTAL	700 in^3

RIBS & FORMERS

FORMER 6

UPPER CAP

$A = .915\ in^2$

$V = (.915)(147) = 135\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = (.915)(147) = 135\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(41-5+37-5+34-5) + (.45)(5+5+5) = 138\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(54-5+54-5+50-5+48-5) + (.45)(5+5+5+5) = 260\ in^3$

ATTACHMENTS

$V = 110(.23) = 25\ in^3$

UPPER CAP	135
LOWER CAP	135
VERTICAL MEMBERS	138
DIAGONAL MEMBERS	260
ATTACH	25
TOTAL	693 in^3

RIBS & FORMERS

FORMER 7

UPPER CAP

$A = .915\ in^2$

$V = (145)(.915) = 133\ in^3$

LOWER CAP

$A = .915\ in^2$

$V = (.915)(145) = 133\ in^3$

VERTICAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45\ in^2$

$V = (1.35)(40-5+37-5+34-5) + (.45)(5+5+5) = 196\ in^3$

DIAGONAL MEMBERS

$A_1 = 1.35\ in^2,\ A_2 = .45$

$V = (1.35)(54-5+50-5+48-5+47-5) + (.45)(5+5+5+5) = 251\ in^3$

ATTACHMENTS

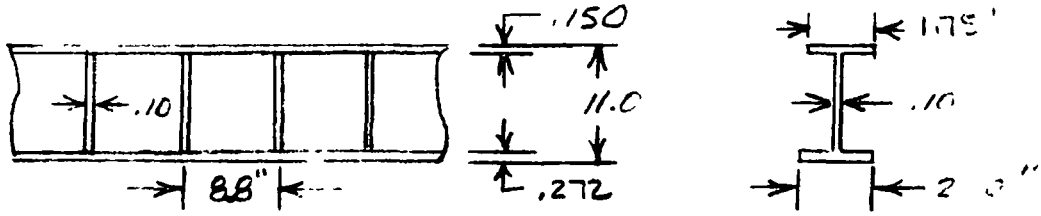
$V = 110(.23) = 25\ in^3$

UPPER CAP	133
LOWER CAP	133
VERTICAL MEMBERS	136
DIAGONAL MEMBERS	251
ATTACH	25
TOTAL	678 in^3

RIBS & FORMERS

FORMERS OUTBOARD OF RIB NO. 2A

UPPER & LOWER MEMBERS



$$V = 10.578 \times .10 + 1.75 \times .150 + 2.00 \times .272 + 10.578 \times \frac{1.75+2.0}{2} \times .10 \div 8.8$$

$$V = 2.09 \quad in^3/in$$

TOTAL UPPER & LOWER CHORD LENGTH OUTBOARD OF RIB NO. 2A

$$\Sigma L = 2 \times (130 + 130 + 128 + 120 + 118 + 112 + 108 + 104 + 94 + 90 + 62) = 2396 \text{ in}$$

$$V = 2396 \times 2.09 = 5008 \text{ in}^3$$

TORQUE BOX TO BODY ATTACH PROVISIONS (½ WING)

REF 899A2010599 SHT 10F8, 30F8

UPPER

BOLT: $(1.0^2 \times .785 \times 4.6 + 1.35^2 \times .785 \times .9) \times 38 \times .286 = 53$ LB

NUT: $(1.35^2 - 1.0^2) .785 \times 38 \times .286 \times 1.0 = 7$ LB

WASHER: $(1.75^2 - 1.0^2) .785 \times .12 \times .1 \times 2 \times 38 = 2$ LB

LOWER

BOLT: $(1.125^2 \times .785 \times 5.6 + 1.55^2 \times .785 \times 1.05) .286 \times 38 = 81$ LB

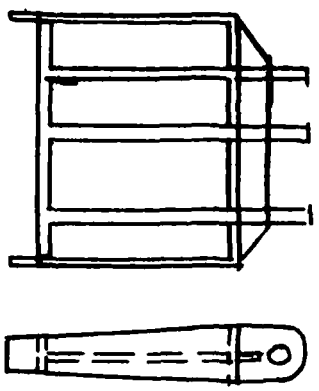
NUT: $(1.65^2 - 1.125^2) \times .785 \times 1.15 \times 38 \times .286 = 14$ LB

WASHER: $(2.0^2 - 1.125^2) \times .2 \times .1 \times 2 \times 38 \times .785 = 3$ LB

TOTAL ½ WING 160 LB

TOTAL WING 320 LB

ACTUATOR FITTING



$V \simeq 270\ in^3$

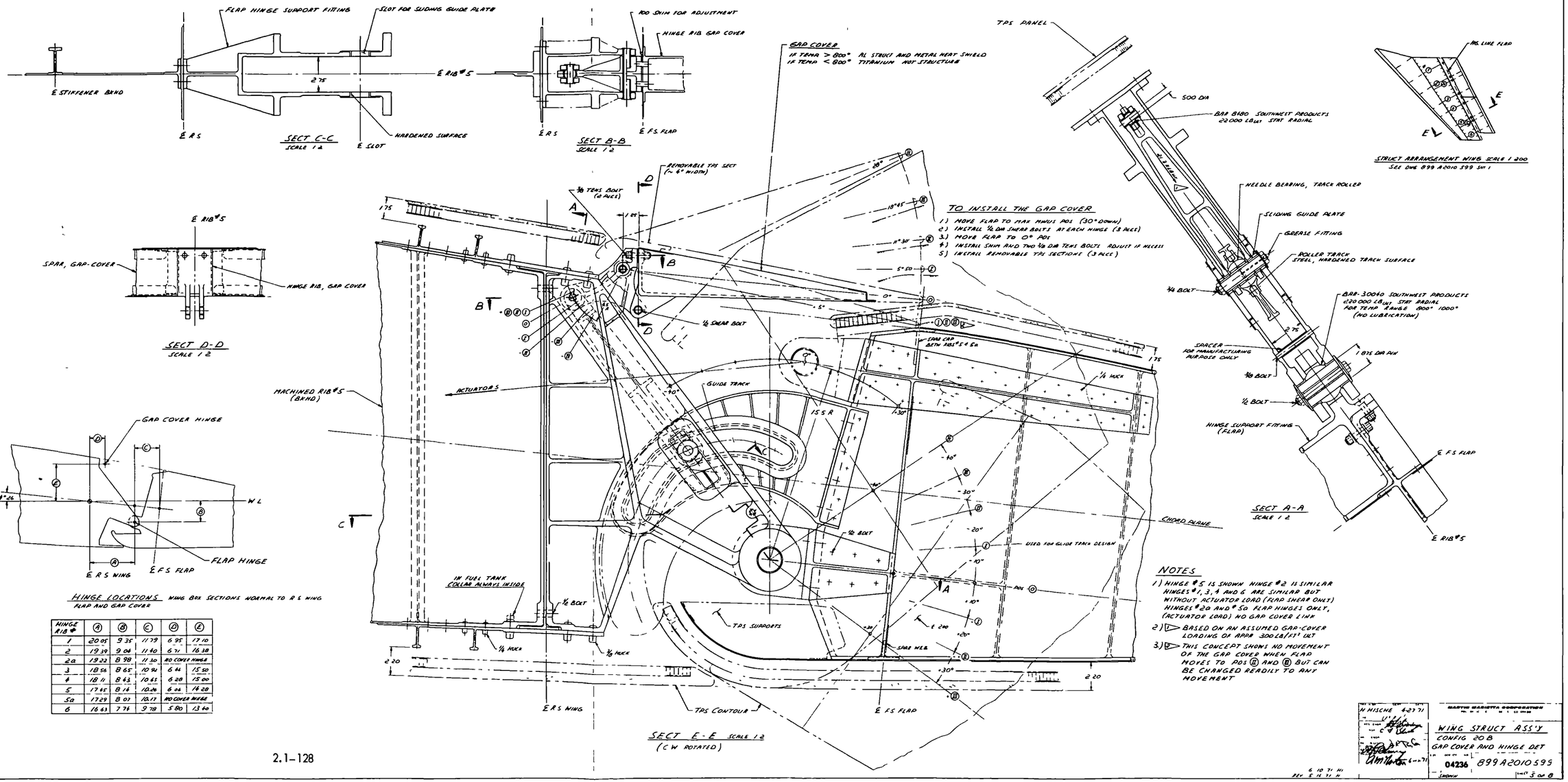
VOLUME – WEIGHT CONVERSION

$W = 270 \times .101 = 27\ LB$

$\Sigma Wt = 2 \times 27 = \underline{54\ LB}$

ATTACH, SPLICES AND JOINTS
SUMMARY

COVER - UPPER - SKIN SPLICE	71
- STR SPLICE	36
- STR SPLICE	36
- LOWER - SKIN SPLICE	71
- STR SPLICE	36
- STR SPLICE	36
FWD SPAR TO SKIN	71
AFT SPAR TO SKIN	71
RIBS	309
TOTAL	737 LB



HINGE RIB #	(A)	(B)	(C)	(D)	(E)
1	20 05	9 35	11 79	6 95	17 10
2	19 39	9 04	11 40	6 71	16 38
2a	19 22	8 98	11 30	NO COVER HINGE	
3	18 56	8 65	10 94	6 44	15 50
4	18 11	8 43	10 65	6 28	15 00
5	17 65	8 16	10 06	6 06	14 28
5a	17 29	8 01	10.17	NO COVER HINGE	
6	16 63	7 76	9 78	5 80	13 46

H HISCHE 4-27-71

MARTIN MARIETTA CORPORATION

WING STRUCT ASS'Y
CONFIG 208
GAP COVER AND HINGE DET

04236 899A2010595

SHEET 3 OF 8

6 10 71 HI
REV 5 14 71 H

TRAILING EDGE (½ WING)

VOLUME-WEIGHT CONVERSION SUMMARY

GAP COVER	.101 x 1464	=	148 LB
OUTBOARD PANEL	.101 x 964	=	97
HINGE FITTINGS	.101 x 1582	=	160
			405
ATTACH., SPLICES	10%		40
			445 LB

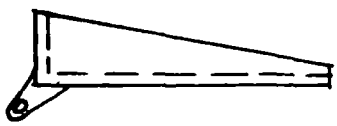
TRAILING EDGE GAP COVER REF 899A2010594 SHT 1 OF 8
5 OF 8

HINGE FITTING

$V = .4 \times 2.8 \times 14 + .4 \times 4.5 \times 2. + 1.8 \times 2.1 \times .5 + 10.6 \times .5 = 12.1 in^3$

$\Sigma V = 6 \times 12 = 72.1 in^3$

HINGE RIB



$V = 27.1 in^3$

$\Sigma V = 6 \times 27 = 162 in^3$

SKIN & SUPPORTS

$\Sigma AREA = 41.3 \times .09 + 1.6 \times .06 \times 2 = 1.85 in^2$

$L = 665 in$

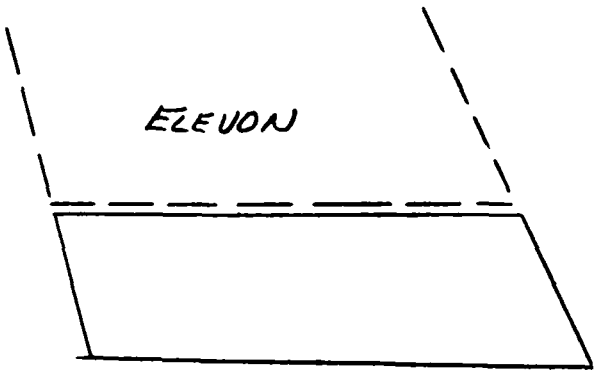
$V = 665 \times 1.85 = 1230 in^3$

TOTAL

$\Sigma V = 72 + 162 + 1230 = 1464 in^3$

TRAILING EDGE

OUTBOARD PANEL



COVERS

$$\text{AREA} = 47 \times 140 = 6580\ in^2$$

$$V = .04 \times 6580 = 263\ in^3$$

$$\Sigma V = 2 \times 263 = 526\ in^3$$

FORMERS

USE ELEVON FORMERS

$$3 \times 130 = 390\ in^3$$

CLOSURE PANEL

$$\text{AREA} = 85 \times 14 = 1190\ in^2$$

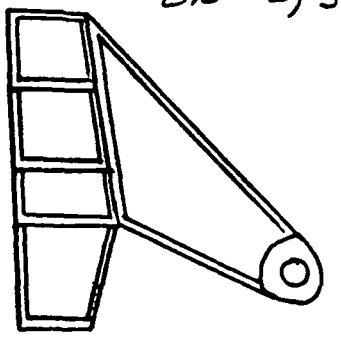
$$V = 1190 \times .09 = 48\ in^3$$

$$\Sigma V = 526 + 390 + 48 = 964\ in^3$$

TRAILING EDGE

HINGE FITTING WITH GAP COVER LINK

ON 2, 5, ?



$V = 3.5 \times 27 \times .25 + 134 \times .25 \times 2$
$+ 4 \times .35 \times 3.5 + 4 \times .35 \times 2.2$
$+ 2 \times 17 \times .35 \times 2$
$+ 18.5 \times 1.35 \times .95 \times 2$
$+ 8.5 \times .6 \times 1.2 \times 2$
$+ 1.6 \times 2 \times 23 \times .65$
$+ (4.8^2 - 1.8^2) \times .785 \times 1.5$
$+ 100 \times .3 \times 2 + 2.3 \times 13 \times 2 \times 2$
$+ 3.2 \times 2.0 \times .3 + 5 \times .6 \times 1.7$
$+ 1.3 \times 6.5 \times .25 = 291 \text{ in}^3$

$\Sigma V = 2 \times 291 = 582 \text{ in}^3$

HINGE FITTINGS GAP COVER LINK, NO ACTUATOR LOAD

1, 3, 4 ≠ 6

$V = .5 \times 291 = 146 \text{ in}^3$

$\Sigma V = 4 \times 146 = 584 \text{ in}^3$

5A ≠ 6A

$V_{5A} = 270 \text{ in}^3$

$V_{6A} = 196 \text{ in}^3$

TOTAL HINGE FITTINGS

$\Sigma V = 582 + 584 + 270 + 146 = 1582 \text{ in}^3$

INBOARD ELEVON (1/2 WING)	(1374)	
TOP COVER SKIN	188	
" " STIFF	38	
BOTTOM COVER SKIN	188	
BOTTOM " STIFF	38	452 LB
HINGE RIBS	60	
ACTUATOR RIBS	108	168 LB
FORMERS	92	
SPARS	258	
END PANELS	48	
HINGE & ACTUATOR FITTINGS	127	
AEROSEAL	50	
ATTACH, JOINTS, SPLICES	179	

INBOARD ELEVON

VOLUME - WEIGHT CONVERSION SUMMARY

TOP COVER SKIN	.101 x 1863	=	188 LB
" " " STIFF.	.101 x 379	=	38
BOTTOM COVER SKIN	.101 x 1863	=	188
" " "	.101 x 379	=	38
HINGE RIB No. 1	.101 x 301	=	30
HINGE RIB No. 3	.101 x 301	=	30
FORMERS	.101 x 910	=	92
ACTUATOR RIBS (2 & 2A)	.101 x 1068	=	108
FORWARD SPAR	.101 x 1413	=	143
AFT SPAR / TRAILING EDGE	.101 x 1140	=	115
END PANELS	.101 x 476	=	48
HINGE FITTING	.101 x 240 + 32 x .286	=	33
HINGE FITTINGS	.101 x 366 + 32 x .286	=	46
ACTUATOR FITTING	.101 x 270	=	27
GUIDE TRACK FITTINGS	.101 x 240	=	21
AEROSEAL	.101 x 497	=	50
			1195 LB
ATTACH, JOINTS SPLICES			179 LB
TOTAL			1374 LB

INBOARD ELEVON

REF 899A2010599 SHT 1 OF 8, 2 OF 8, 5 OF 8, 7 OF 8, 8 OF 8

TOP COVER

SKIN

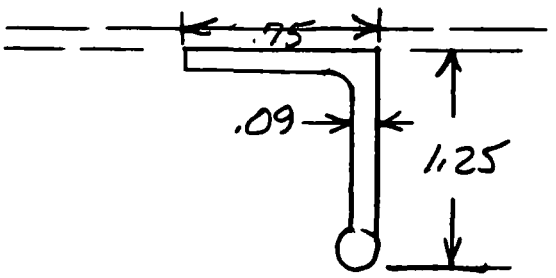
$$AREA = 90 \times 300 + \frac{1}{2} \times 45 \times 90 + \frac{1}{2} \times 95 \times 90$$

$$= 31050 \text{ in}^2$$

$$t = .06 \text{ in}$$

$$V = .06 \times 31050 = 1863 \text{ in}^3$$

SKIN STIFFENERS



$$A = (.75 + 1.25) \times .09 = .18 \text{ in}^2$$

$$\Sigma L = 25 + 45 + 65 + 20 \times 90 + 70 + 52 + 35 + 15$$

$$= 2107 \text{ in.}$$

$$\Sigma V = .18 \times 2107 = 379 \text{ in}^3$$

BOTTOM COVER

SKIN

USE S/A TOP COVER SKIN

$$V = 1863 \text{ in}^3$$

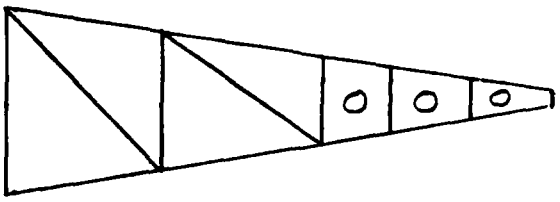
SKIN STIFFENERS

USE S/A TOP COVER SKIN

$$V = 379 \text{ in}^3$$

INBOARD ELEVON

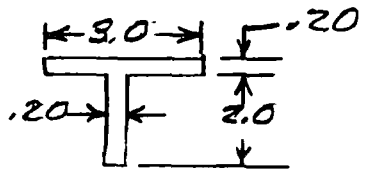
HINGE RIBS



HINGE RIB No. 1

CAPS

$L = 82$ in.



$A = (3.0 + 2.0) \times .20 = 1.0 \text{ in}^2$

$V_{\text{BOTH CAPS}} = 2 \times 82 \times 1.0 = 164 \text{ in}^3$

END MEMBERS

$\Sigma L = 27 + 2 = 29$ in.

$A = 1.25$

$V = 29 \times 1.25 = 36 \text{ in}^3$

DIAGONAL MEMBERS

$\Sigma L = 33 + 30 = 63$ in.

$A = .80 \text{ in}^2$

$V = 63 \times .8 = 50 \text{ in}^2$

VERTICAL MEMBERS

$\Sigma L = 22 + 14 = 36$ in

$V = .80 \times 36 = 29 \text{ in}^3$

INBOARD ELEVON

HINGE RIB NO. 1 (CONT.)

AFT WEB

$$\text{AREA} = \frac{13+1.5}{2} \times 35 = 254 \text{ in}^2$$

$$t = .07$$

$$V = 254 \times .07 = 18 \text{ in}^3$$

WEB STIFFENERS

$$\Sigma H = 10 + 8 = 18 \text{ in}$$

$$A = 3.0 \times .07 = .21 \text{ in}^2$$

$$V = 18 \times .21 = 4 \text{ in}^3$$

TOTAL

$$\Sigma V = 164 + 36 + 50 + 29 + 18 + 4 = 301 \text{ in}^3$$

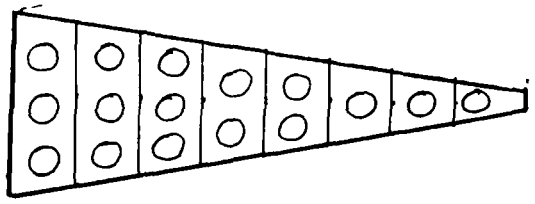
HINGE RIB NO. 3

USE S/A HINGE RIB NO. 1

$$V = 301 \text{ in}^3$$

INBOARD ELEVON FORMERS

TYPICAL FORMER



WEB

$$A = \frac{26+1}{2} \times 84 - 3.5^2 \times .785 \times 16 + 84 \times .8 \times 2 = 1114 \text{ in}^2$$

$$V = .07 \times 1114 = 78 \text{ in}^3$$

WEB STIFFENERS

$$A = 2.5 \times .08 = .20 \text{ in}^2$$

$$\Sigma H = 116 \text{ in}$$

$$V = 116 \times .20 = 23 \text{ in}^3$$

CAPS

$$\Sigma L = 2 \times 82 = 164 \text{ in.}$$

$$A = 1.75 \times .07 = .12 \text{ in}^2$$

$$V = 164 \times .12 = 20 \text{ in}^3$$

END EDGE MEMBERS

$$\Sigma H = 27 + 2 = 29 \text{ in.}$$

$$A = 3.0 \times .1 = .3$$

$$V = 29 \times .3 = 9 \text{ in}^3$$

TOTAL

$$\Sigma V = 78 + 23 + 20 + 9 = 130 \text{ in}^3$$

INBOARD ELEVON

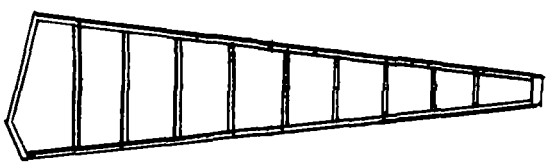
FORMERS (CONT)

(7) FORMERS

$\Sigma V = 7 \times 130 = 910 \text{ in}^3$

ACTUATOR RIBS

MACHINED RIB NO. 2



CAPS

$w = 3.0$, $t = .15$ in.

$\Sigma L = 182$ in

$V = 182 \times 3.0 \times .3 = 164 \text{ in}^3$

END EDGE MEMBERS

FWD END

$V = 4.0 \times (16.5 \times .5 + 5.5 \times .5 + 4.5 \times .45)$

$= 52 \text{ in}^3$

AFT END

$V = 4. \times 2.3 \times .2 = 2. \text{ in}^3$

INBOARD ELEVON

ACTUATOR RIB (CONT.)

WEB

$$\text{AREA} = \frac{21+2.8}{2} \times 81 + 27 \times 11 = 1261 \text{ in}^2$$

$$t = .20 \text{ in}$$

$$V = .20 \times 1261 = 252 \text{ in}^3$$

WEB STIFFENERS

$$\Sigma H = 158 \text{ in.}$$

$$w = 1.5 \text{ in.}, \quad t = .25 \text{ in}$$

$$V = 158 \times 1.5 \times .25 = 60 \text{ in}^3$$

FILLET MATERIAL

$$\Sigma L = 4 \times 182 + 24 \times 2 + 158 \times 4 = 632 \text{ in}$$

$$A = .2146 \times .156^2 \times 632 = 4 \text{ in}^3$$

TOTAL

$$\Sigma V = 164 + 52 + 2 + 252 + 60 + 4 = 534 \text{ in}^3$$

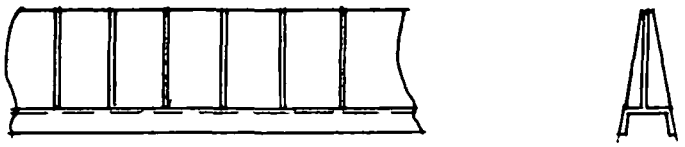
ACTUATOR RIB NO 2A

USE S/A ACTUATOR RIB NO. 2

$$V = 534 \text{ in}^3$$

INBOARD ELEVON

AFT SPAR / TRAILING EDGE MEMBER



BASIC CROSS SECTIONAL AREA

$(13.0 \times .15 + 2.6 \times .125 + 2 \times 2.4 \times .125) = 2.875\ in^2$

TPS SUPPORT GUSSETS

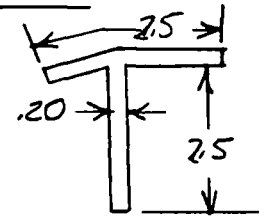
$V = \frac{1.12}{2} \times 13 \times .15 \times 2 \div 5 = .44\ in^3/in$

$L = 344\ in.$

$V = 344 \times (2.875 + .44) = 1140\ in^3$

FORWARD SPAR

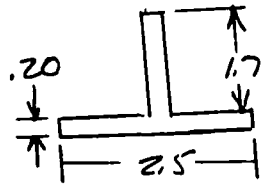
CAPS



$A = 5.0 \times .20 = 1.0\ in^2$

$L = 344\ in$

$V = 344 \times 1.0 = 344\ in^3$



$A = 4.2 \times .20 = .84\ in^2$

$L = 344\ in$

$V = 344 \times .84 = 289\ in^3$

INBOARD ELEVON

FORWARD SPAR (CONT.)

WEB

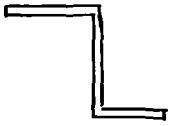
$t = .060$ in

$A = 344 \times 27 = 9288$ in^2

$V = .060 \times 9288 = 557$ in^3

WEB STIFFENERS

$\Sigma H = \frac{344}{10} \times 27 = 929$ in.



$A = 3.0 \times .08 = .24$ in^2

$V = 929 \times .24 = 223$ in^3

TOTAL

$\Sigma V = 344 + 289 + 557 + 223 = 1413$

INBOARD ELEVON

END CLOSING PANELS

USE FORMERS + SKIN

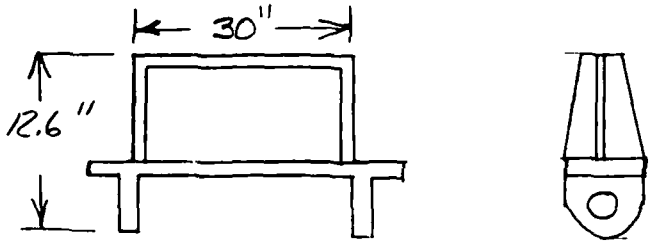
SKIN

$V = .06 \times 90 \times 20 = 108 in^3$

$\Sigma V = 2 \times (108 + 130) = 476 in^3$

INBOARD ELEVON

HINGE FITTINGS — RIB 2 TO RIB 2A

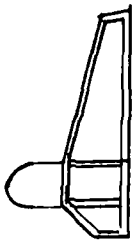


$V = 5.4 \times .48 \times 34 + 3.0 \times .4 \times 30$
$+ 5.8 \times .36 \times 29 + 5.9 \times 4.3 \times .45$
$+ (2.8 \times 5.45 \times 1.25 + 2.75^2 \times \pi \times .5 \times 1.25) \times 2$
$- 2.8^2 \times .785 \times 1.25 \times 2 + .25^2 \times .2196 \times 200$
$= 240 \text{ in}^3$

STEEL BALL-PIN

$V = (1.875^2 \times .785 \times 9.2 + 2.3\pi \times 1.8 \times .35) \times 2$
$= 32 \text{ in}^3$

RIBS NO 1 & NO. 3



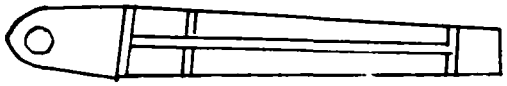
$V = 95 \times .5 \times 2.5 + 27 \times .4 \times 2.5$
$+ 5.5 \times .5 \times 2.5 + 14 \times .35 \times 2.5$
$+ 5.X3 \times 2.0 + 2.75^2 \times \pi \times .5 \times 2.0$
$- 1.9^2 \times \pi \times 2.0 + 12.5 \times 6 \times .4$
$+ 5 \times 7 \times .4 + 4.5 \times 4 \times .4 = 183$

STEEL-BALL-PIN

$V = 16 \text{ in}^3$

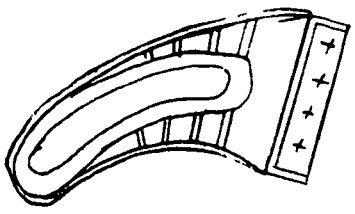
INBOARD ELEVON

ACTUATOR FITTING



$V \approx 270\ in^3$

GUIDE TRACK FITTING



$V = .25 \times 9 + 1.0 \times .2 \times 45$
$+ .6 \times .15 \times 16 + .9 + .5 \times 36$
$+ 36 \times .43 + 1.5 \times 9 \times .25$

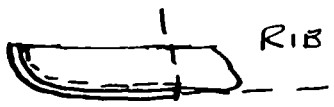
$V = 70\ in^3$

$\Sigma V = 4 \times 70 = 280\ in^3$

INBOARD ELEVON

AERO SEAL

SKIN



$A = 18 \times 344 = 6192\ in^2$

$V = .06 \times 6192 = 372\ in^3$

SUPPORTS

$A = 65\ in^2$

$V = .06 \times 65 = 4\ in^3$

$\Sigma V = 20 \times 4 = 80\ in^3$

$\Sigma V = 372 + 80 = 452\ in^3$

ATTACH	45
TOTAL	497

OUTBOARD ELEVON (½ WING)	[1341]	
TOP COVER SKIN	183	
TOP COVER STIFF	37	
BOTTOM COVER SKIN	183	
BOTTOM COVER STIFF	37	440 LB
HINGE RIBS	62	
ACTUATOR RIBS	108	170
FORMERS	92	
SPARS	265	
END PANELS	48	
HINGE & ACTUATOR FTGS	128	
AERO SEAL	46	
ATTACH. JOINTS, SPLICES	181	

OUTBOARD ELEVON REF 899A2010599 SHT 1 OF 8, 2 OF 8, 5 OF 8, 7 OF 8, 8 OF 8

HINGE FITTINGS – RIBS 4 & 6

$\Sigma V = 366\ in^3$ AL + $32\ in^3$ ST (FROM INB'D ELEV)

ACTUATOR FITTING

$V = 258\ in^3$ (FROM INB'D ELEVON)

GUIDE TRACK FITTINGS

$\Sigma V = 140\ in^3$ (FROM INB'D ELEVON)

WEIGHT SUMMARY

TOP COVER SKIN	.101 × 1803	=	183 LB
TOP COVER " STIFF.	.101 × 363	=	37
BOTTOM COVER SKIN	.101 × 1803	=	183
BOTTOM COVER STIFF	.101 × 363	=	37
HINGE RIB No. 4	.101 × 301	=	31
HINGE RIB No. 6	.101 × 301	=	31
FORMERS	.101 × 910	=	92
ACTUATOR RIBS 5 & 5A	.101 × 1068	=	108
FORWARD SPAR	.101 × 1294	=	131
AFT SPAR/TRAILING EDGE	.10 × 1044	=	105
END PANELS	.101 × 476	=	48
HINGE FITTING 5 & 5A	.101 × 240 + 32 × .286	=	34
HINGE FITTINGS 4 & 6	.101 × 366 + 32 × .286	=	46
ACTUATOR FITTING	.101 × 270	=	27
GUIDE TRACK FITTINGS	.101 × 210	=	21
AERO SEAL	.101 × 455	=	46
			1160
ATTACH, SPLICES, JOINTS			181
TOTAL			1341 LB

OUTBOARD ELEVON

TOP COVER

SKIN

$$\text{AREA} = 90 \times 290 + \tfrac{1}{2} \times 45 \times 90 + \tfrac{1}{2} \times 45 \times 90$$

$$= 30150.1^2$$

$t = .060$ in

$V = .060 \times 30150 = 1809$ in^3

SKIN STIFFENERS

$\Sigma L = 2017$ in

$A = .18$ in^2 (FROM INB'D ELEVON)

$V = 2017 \times .18 = 363$ in^3

BOTTOM COVER

SKIN

USE S/A TOP COVER SKIN

$V = 1809$ in^3

SKIN STIFFENERS

USE S/A TOP COVER STIFF.

$V = 363$ in^3

HINGE RIBS 4

$V = 301$ in^3 (FROM INBOARD ELEVON)

HINGE RIB 6

$V = 301$ in^3 (FROM INBOARD ELEVON)

AERO SEAL

$V = \frac{497}{344} \times 315 = 455$ in^3 (FROM INBOARD ELEVON)

OUTBOARD ELEVON

FORMERS

$V_{EACH} = 130 in^3$ (FROM INBOARD ELEVON)

$\Sigma V = 7 \times 130 = 910 in^3$

ACTUATOR RIB No. 5

$V = 534 in^3$ (FROM INBOARD ELEVON)

ACTUATOR RIB No. 5A

$V = 534 in^3$ (FROM INBOARD ELEVON)

AFT SPAR / TRAILING EDGE MEMBER

$V = 3.315 in^3/in$ (FROM INBOARD ELEVON)

$L = 315$ in.

$V = 3.315 \times 315 = 1044 in^3$

FORWARD SPAR

$V = 1413 \div 344 = 4.108 in^3/in$ (FROM INBOARD ELEV)

$V = 315 \times 4.108 = 1294 in^3$

END CLOSING PANELS

$\Sigma V = 476 in^3$ (FROM INBOARD ELEVON)

HINGE FITTING ~ RIB 5 TO 5A

$V = 240 in^3$ AL + $32 in^3$ ST

2. TAIL GROUP 19214

		WEIGHT (LB) PER BOOSTER	PAGE NO.
DORSAL FIN	[2,852]	[5,704]	2.2-8
LEADING EDGE	(481)		2.2-14
NOSE	231		
COVERS	133		
SPAR	38		
RIBS	21		
FORMERS	20		
ATTACH, JOINTS	38		
TORQUE BOX	(1,126)		2.2-17
COVERS	493		
SPARS	136		
RIBS	135		
FORMERS	34		
WING ATTACH PROV.	178		
FITTINGS	30		
ATTACH, SPLICE, JOINT	120		
TRAILING EDGE (SUPT/MECH)	(213)		2.2-29
GAP COVER	60		
LOWER PANEL	54		
FITTINGS	80		
ATTACH, SPLICES, JOINTS	19		
RUDDER (STR)	(1,032)		2.2-30
COVERS	305		
RIBS	226		
FORMERS	82		
SPARS	105		
T.E. MEMBER	81		
FITTINGS	95		
ATTACH, JOINTS, SPLICES	138		

TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
VENTRAL FIN	[2,865]	[5,730]	2.2-35
LEADING EDGE	(577)		2.2-38
NOSE	308		
COVER	150		
RIBS	34		
FORMERS	15		
SPAR	45		
ATTACH, JOINTS, SPLICE	25		
TORQUE BOX	(1,655)		2.2-47
COVERS	950		
SPARS	195		
RIBS	143		
FORMERS	48		
WING ATTACH PROVISIONS	169		
ATTACH, SPLICES, JOINTS	150		
TRAILING EDGE	(633)		2.2-58
COVERS	396		
SPAR	73		
RIBS	63		
FORMERS	41		
ATTACH, SPLICE, JOINT	60		
CANARD		[7,780]	2.2-66
TORQUE BOX		(3,944)	
COVERING (UPPER)	(701)		2.2-84
SKIN	332		
STRINGERS	322		
SPLICES, ATTACHMENTS (JSF)	47		
FORWARD SPAR	(716)		
SHEAR WEB	117		
WEB STIFFENERS	253		
CAPS	298		
SPLICES, ATTACHMENTS (JSF)	48		

TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
AFT SPAR	(609)		
SHEAR WEB	113		
WEB STIFFENERS	215		
CAPS	235		
SPLICES ATTACHMENTS (JSF)	46		
RIBS (12)	(1,067)		
SHEAR WEB	581		
WEB STIFFENERS (INTEGRAL)	338		
CAPS (INTEGRAL)	67		
FILLETS, BOSSES, ATTACHMENTS	81		
REMOVABLE PANELS (LOWER) (10)	(568)		
STRUCTURE	278		
MECHANISM	290		
TIPS	(211)		
BODY ATTACHMENT	(72)		
UPPER SKIN	5		
FORWARD SPAR CAPS	43		
AFT SPAR CAPS	24		
LEADING EDGE		(1,850)	2.2-97
FORWARD EDGE (HOT)	(423)		
COVER	274		
BEAMS	56		
INSULATION	8		
SEAL	30		
SPLICES, ATTACHMENTS	55		
COVERS	(357)		
SKIN	195		
STRINGERS	87		
STIFFENERS	11		
SPLICES, ATTACHMENTS	64		

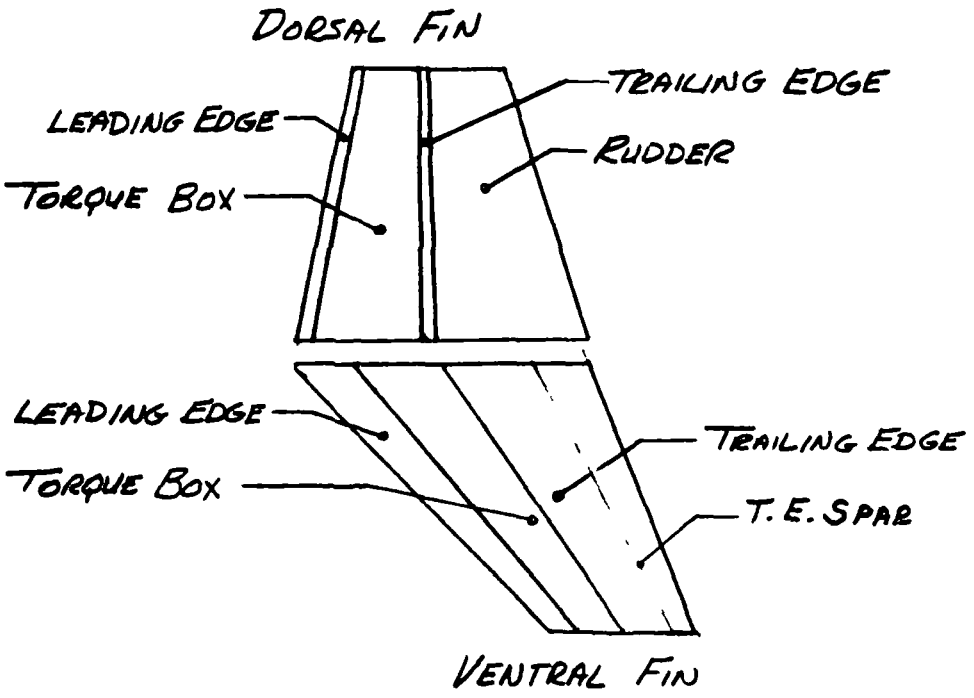
TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
SPAR	(168)		
WEB	39		
STIFFENERS	10		
CAPS	89		
SPLICES, ATTACHMENTS	30		
RIBS	(130)		
FORMERS	(107)		
INLET LIP (MOVABLE)*	(665)		
FORWARD EDGE (HOT)	254		
COVERS	136		
SPARS	125		
RIBS	71		
RAMPS (ENGINE AIR DUCTS)	25		
SPLICES, ATTACHMENTS	54		
TRAILING EDGE		(380)	2.2-101
COVERS	(165)		
SKIN	95		
STRINGERS	19		
SPLICES, ATTACHMENTS	51		
RIBS	(154)		
FORMERS	(61)		
JET FLAPS (STRUCT) - 10		(1,149)	2.2-107
COVERS	(647)		
SKIN	224		
CORRUGATION	299		
SPLICES, ATTACHMENTS	124		
SPAR	(135)		
WEB	55		
CAPS	54		
SPLICES, ATTACHMENTS	26		

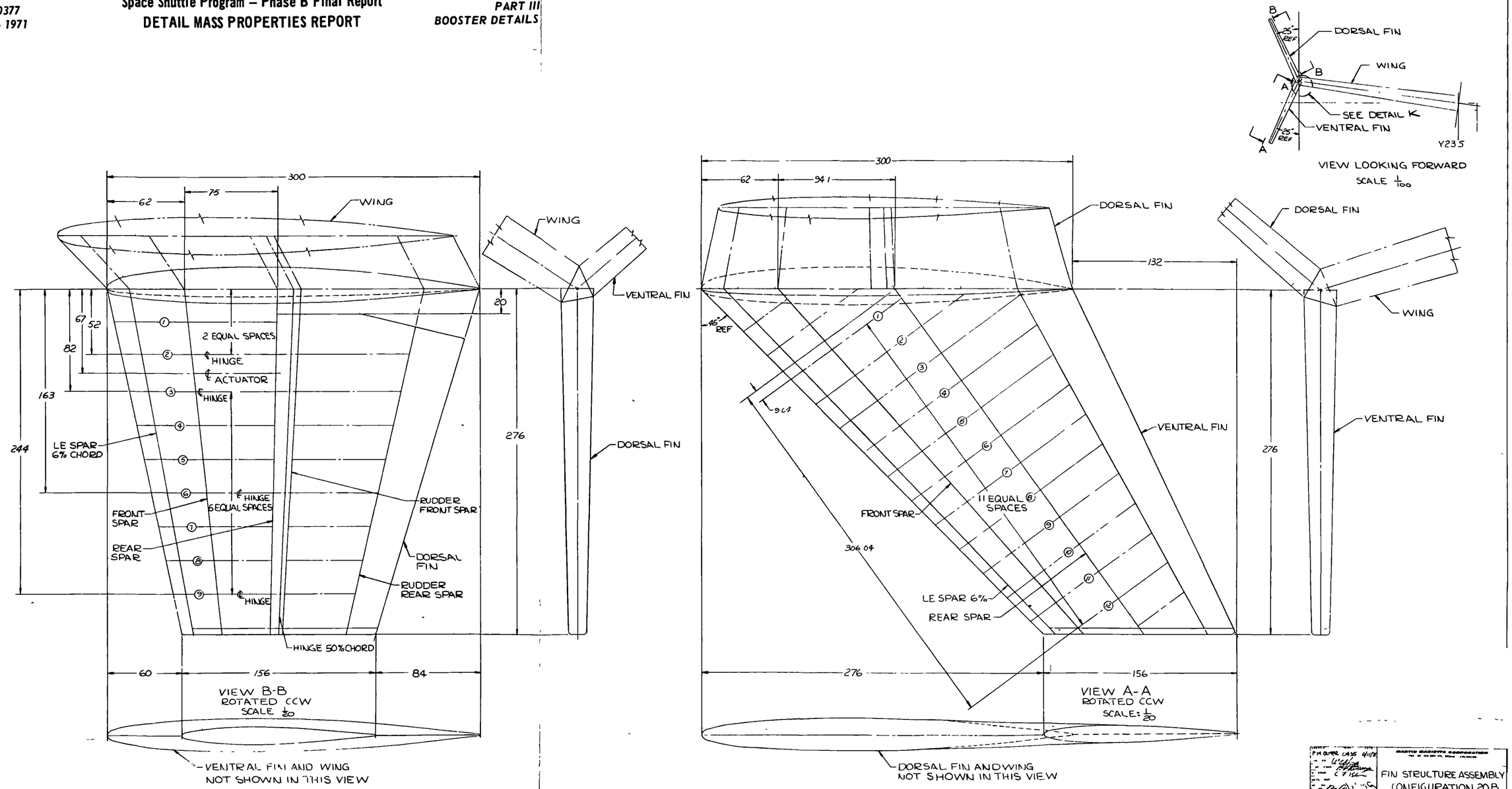
*EXCLUDES HINGE & CONTROL FTGS. WHICH ARE IN ENG. AIR INDUCTION.

TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
TRAILING EDGE MEMBER	24		
RIBS	287		
FLAP INTERCONNECTION (FLEX. SKIN)	56		
JET FLAP SUPPORTS		(457)	2.2-112
HINGE FITTINGS	(170)		
CONTROL FITTING	(287)		



	VENTRAL VERTICAL	DORSAL VERTICAL	DORSAL HORIZ	
2. TAIL GROUP				
BASIC STRUCTURE	(5730)	(3214)	(6174)	15118
TORQUE BOX	3310	2252	3944	
CARRY THROUGH				
LEADING EDGE	1154	962	1650	
TRAILING EDGE	1266		380	
SECONDARY STRUCTURE				
CONTROL SURFACES		SURFACE	SUPT/MECH	4096
RUDDERS		2064	426	
JET FLAPS		1149	457	


DORSAL FIN
WING
SEE DETAIL K
VENTRAL FIN
Y23.5
VIEW LOOKING FORWARD
SCALE 1/100
WING
VENTRAL FIN
DORSAL FIN
2 EQUAL SPACES
HINGE
ACTUATOR
LE SPAR 6% CHORD
FRONT SPAR
REAR SPAR
6 EQUAL SPACES
RUDDER FRONT SPAR
RUDDER REAR SPAR
HINGE 50% CHORD
VIEW B-B
ROTATED CCW
SCALE 1/20
VENTRAL FIN AND WING NOT SHOWN IN THIS VIEW
11 EQUAL SPACES
LE SPAR 6%
VIEW A-A
ROTATED CCW
SCALE: 1/20
DORSAL FIN AND WING NOT SHOWN IN THIS VIEW
FIN STRUCTURE ASSEMBLY
CONFIGURATION 20B
04236
899A2010641
1 OF 4

		WEIGHT (LB) PER BOOSTER
DORSAL FIN	[2,852]	[5,704]
LEADING EDGE	(481)	
NOSE	231	
COVERS	133	
SPAR	38	
RIBS	21	
FORMERS	20	
ATTACH, JOINTS	38	
TORQUE BOX	(1,126)	
COVERS	493	
SPARS	136	
RIBS	135	
FORMERS	34	
WING ATTACH PROV.	178	
FITTINGS	30	
ATTACH, SPLICE, JOINT	120	
TRAILING EDGE (SUPT/MECH)	(213)	
GAP COVER	60	
LOWER PANEL	54	
FITTINGS	80	
ATTACH, SPLICES, JOINTS	19	
RUDDER (STR)	(1,032)	
COVERS	305	
RIBS	226	
FORMERS	82	
SPARS	105	
T.E. MEMBER	81	
FITTINGS	95	
ATTACH, JOINTS, SPLICES	138	

DORSAL FIN AND VENTRAL FIN DETAILED WEIGHT SUBSTANTIATION

FIN WEIGHT SUBSTANTIATION IS PRESENTED ON THE FOLLOWING PAGES. WEIGHTS HAVE BEEN ARRIVED AT BY USE STRESS ANALYSIS INPUT, DESIGN DRAWINGS, AND WEIGHT ESTIMATES. A LARGE PERCENTAGE OF THE FIN WEIGHT CALCULATIONS IS BASED ON STRESS ANALYSIS INPUT. THE STRESS ANALYSTS' GRAPHS AND TABLES ARE INCLUDED IN THE FOLLOWING PAGES. ITEMS SUCH AS JOINTS, SPLICES, AND ATTACHMENTS ARE ESTIMATED BASED ON THE TYPE OF STRUCTURAL CONSTRUCTION FOR SOME ITEMS SUCH AS WEB STIFFENERS, FRAMES ETC. WEIGHTS ARE BASED STRESS, DESIGN, AND WEIGHT ENGINEERS' JUDGEMENT.

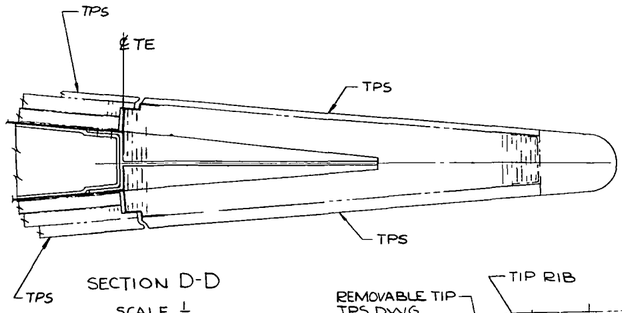
ALL STRUCTURE IS FABRICATED FROM AL 2014-T73 WHICH HAS A DENSITY OF 0.101 LB/IN^3. IN ADDITION TO THE INCLUDED STRESS TABLES AND GRAPHS, THE FOLLOWING DRAWINGS SHOULD BE REFERENCED:

MMC 899A2010 641 - 1 OF 4, 2 OF 4, 3 OF 4
& 4 OF 4

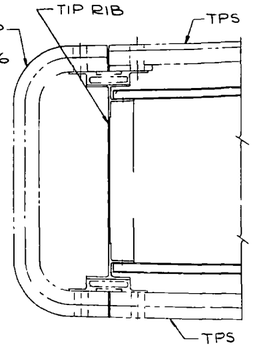
ALSO INCLUDED IN THE FOLLOWING PAGES ARE TABLES WHICH COMPARE THESE FIN WEIGHTS WITH FIN WEIGHTS OF OTHER VEHICLES.

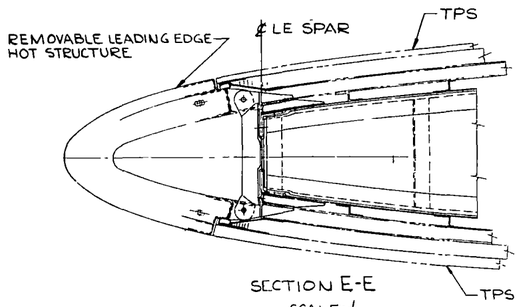
FIN UNIT WEIGHT COMPARISON

	UNIT WEIGHT LB/FT^2	
	RUDDER	TOTAL FIN
SPACE SHUTTLE		
DORSAL	5.63	6.52
VENTRAL	~	6.56
B47	5.8	5.1
B-52	5.5	5.3
C-135	3.5	5.95
C-133	-	3.65
DC-9	5.5	6.57
727	3.4	5.55
C-141	2.7	6.79
C-5A	3.0	6.75
C-130	4.6	4.10



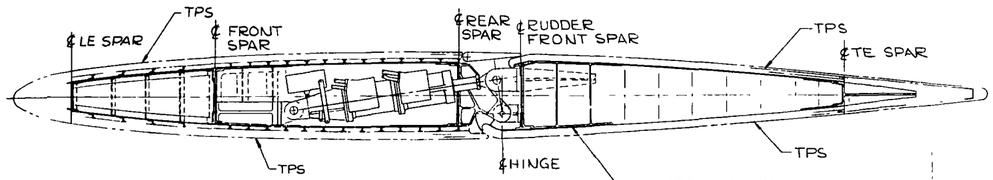
SECTION D-D
SCALE 1/2



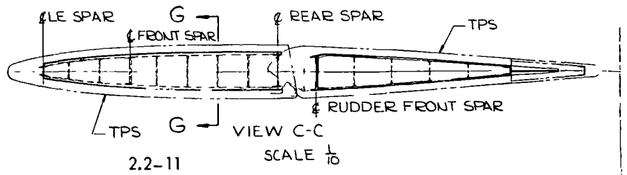


SECTION E-E
SCALE 1/2

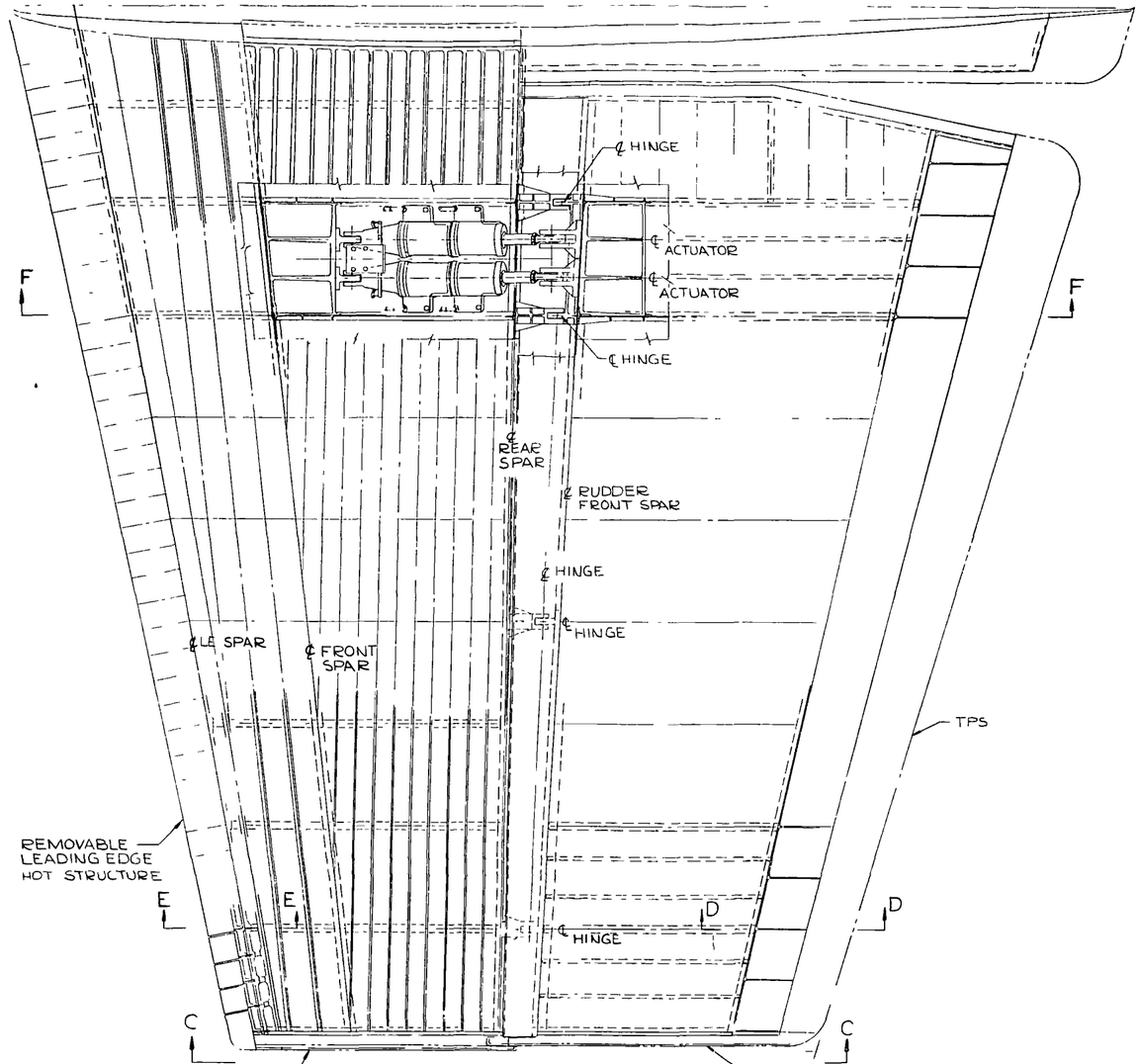
SECTION G-G
SCALE 1/2



SECTION F-F
SCALE 1/10



VIEW C-C
SCALE 1/10



PLAN VIEW - DORSAL FIN
SCALE 1/10

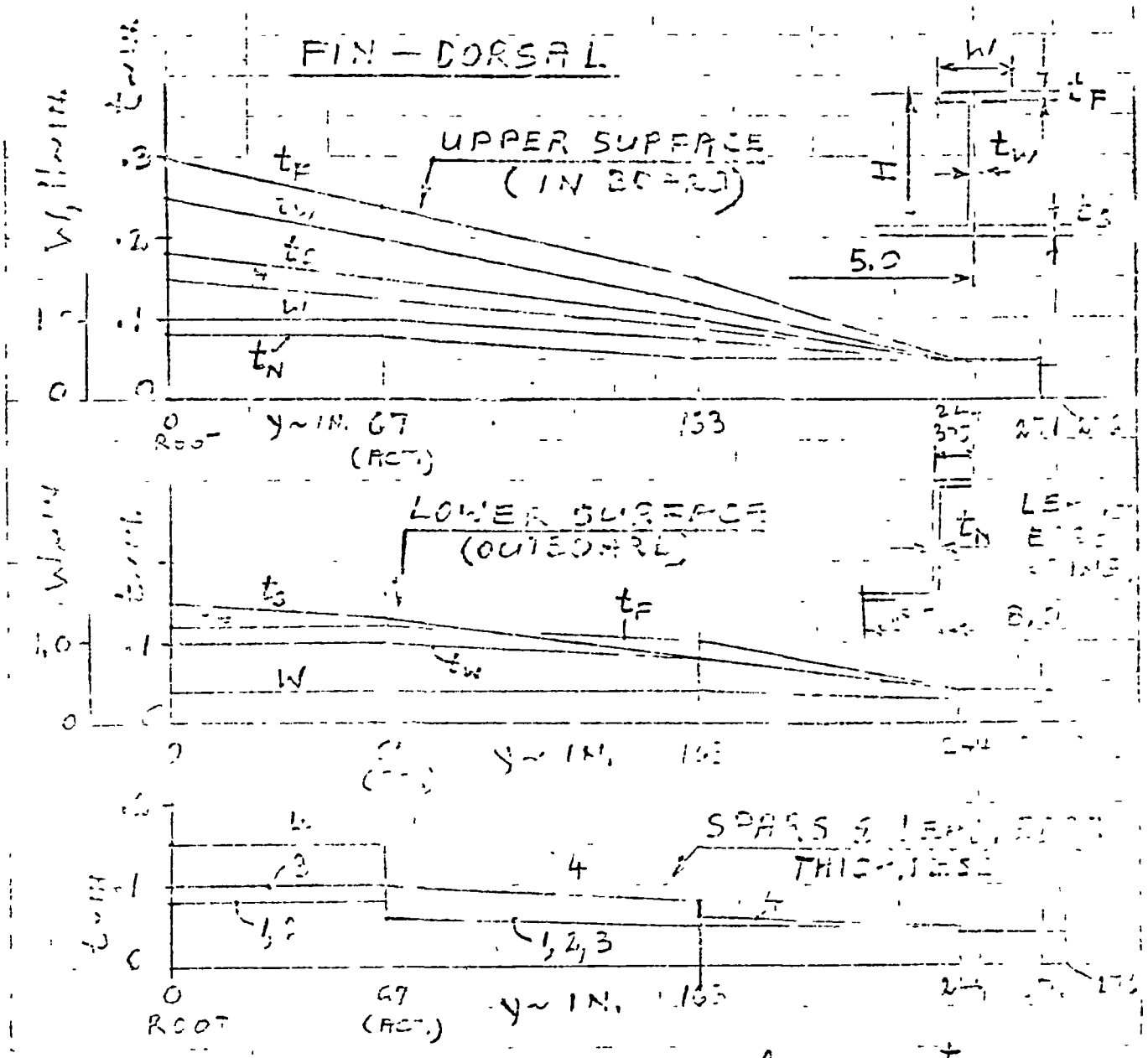
MARTIN MARIETTA CORPORATION

FIN STRUCTURE ASSEMBLY
CONFIGURATION 20B

J 04236 899A2010641

SHEET 3 OF 4

STRUCTURAL SIZES - FIN
CONFIG. # 2.0 B



ROOT	.090	.100
67	.080	.090
163	.060	.050
244	.050	.050
271	.040	.040

RIB THICKNESS, IN.

MAT. FOR PLATES ~ TI

STRUCTURAL SIZES - FIN (CONT)

Y~IN	t_F IN	t_W IN	t_S IN	t_N IN	W IN	H IN
ROOT	.300	.250	.180	.080	1.0	1.50
67	.240	.200	.150	.080	1.0	↕
163	.150	.120	.100	.050	.75	↕
244	.050	.050	.050	.050	↕	↕
271	.050	.050	.050	.050	.40	.50
276	/	/	.040	/	/	/

UPPER (INBD)

Y~IN	t_F IN	t_W IN	t_S IN	t_N IN	W IN	H IN
ROOT	.120	.100	.150	.060	.40	1.50
67	.120	.100	.130	.060	.40	↕
163	.100	.080	.080	.050	.40	↕
244	.040	.040	.040	.050	.250	↕
271	.040	.040	.040	.050	.250	.50
276	/	/	.040	/	/	/

LOW. SURF. (OUTBD)

Y~IN	LEAD. EDGE (1)	F.S. (3)	R.S (4)
ROOT	.080	.100	.150
67	.080 .060	.100 .060	.150 .100
163	.050	.050	.080 .060
244	.050 .040	.050 .040	.050 .040
271	.040	.040	.040
276	/	.040	.040

SPAR-THICKNESS ~ IN.

DORSAL FIN

LEADING EDGE SUMMARY

COVER - SKIN	107
COVER - STRINGERS	26
RIBS	21
FORMERS	20
L.E. SPAR	38
ATTACH, JOINTS, SPLICES	38
NOSE (HOT STRUCTURE - HASTELLOY)	231
TOTAL FOR 1	481 LB

2.2-14

LEADING EDGE

L.E. SPAR

WEB STIFFENERS

STA 5 TO 67: $V = 9.4 \times \frac{63}{8} \times .09 \times 2.5 = 17 \text{ in}^3$

STA 67 TO 163: $V = 8.1 \times \frac{97.5}{8} \times .07 \times 2.5 = 17$

STA 163 TO 244: $V = 5.8 \times \frac{82}{8} \times .063 \times 2.5 = 9$

STA 249 TO 274: $V = 4.4 \times \frac{32.5}{8} \times .05 \times 2.5 = 2$

$\Sigma V = 45 \text{ in}^3$, $WT = .101 \times 45 = 5 \text{ LB}$

CAPS

STA 5 TO 67: $V = 2 \times 63 \times .125 \times 3.5 = 55 \text{ in}^3$

STA 67 TO 163: $V = 2 \times 97.5 \times .10 \times 3.5 = 68 \text{ in}^3$

STA 163 TO 244: $V = 2 \times 82 \times .10 \times 3.5 = 57 \text{ in}^3$

STA 244 TO 276: $V = 2 \times 32.5 \times .08 \times 3.5 = 18$

$\Sigma V = 198 \text{ in}^3$, $WT = 198 \times .101 = 20 \text{ LB}$

TOTAL SPAR WT = 20 + 5 + 13 = **38 LB**

RIBS

WEB STIFFENERS & CAPS

STA 7 TO 67 $V = 44 \times 2 \times 3.5 \times .09 + \frac{44}{8} \times 144 \times 2.5 \times .09 = 46 \text{ in}^3$

STA 67 TO 163 $V = 39.5 \times 2 \times 3.5 \times .063 + \frac{30.5}{8} \times 11.7 \times 2.5 \times .063 = 27 \text{ in}^3$

STA 163 TO 244 $V = 28 \times 2 \times 3.5 \times .05 + \frac{28}{8} \times 8.7 \times 2.5 \times .05 = 14$

STA 244 TO 271 $V = 24.5 \times 2 \times 3.5 \times .05 + \frac{24}{8} \times 6.9 \times 2.5 \times .05$ 11

$\Sigma V = 98 \text{ in}^3$, $WT = .101 \times 98 = 10 \text{ LB}$

TOTAL RIB WT = 10 + 11 = **21 LB**

LEADING EDGE

FORMERS

STA 7 TO 67:

(2)
WEB $V = 19.4 \times 41 \times .04 =$ 24 in³
WEB STIFF $V = 19.4 \times \frac{41}{8} \times .05 \times 2 =$ 7
CAPS $V = 2 \times 41 \times .05 \times 3.0 =$ 12
43 × 2 = 86 in³

STA 67 TO 163

(2)
WEB $V = 35 \times 11.7 \times .04 =$ 16
WEB STIFF. $V = 11.7 \times \frac{35}{8} \times .05 \times 2 =$ 5
CAPS $V = 2 \times 35 \times .05 \times 3.0 =$ 11
32 × 2 = 64 in³

STA 163 TO 249

(2)
WEB $V = 28.5 \times 8.7 \times .04 =$ 10
WEB STIFF $V = 8.7 \times \frac{28.5}{8} \times .05 \times 2.0 =$ 3
CAP $V = 28.5 \times 2 \times .05 \times 3.0 =$ 9
22 × 2 = 44 in³

$\Sigma V = 194 \text{ in}^3$, $WT = .101 \times 194 = 20$ LB.

Torque Box

Cover Skin-Inboard	199
Cover Stringers-Inboard	85
Cover Skin-Outboard	173
Cover Stringers-Outboard	36
Front Spar	53
Aft Spar	83
Ribs	135
Formers	34
Wing-Ventral Fin Intersect Provision	128
Attach, Splices, Joints	120
Wingfin Attach Bolts, Nuts	50
Actuator Fitting	30
	1126

Total Cover Weight = 199 + 85 + 173 + 36

= 493 LB

Spars Weight = 53 + 83 = 136 LB

Wing Intersection Attach Provisions = 128 + 50 = 178 LB

DORSAL WEIGHT SUBSTANTIATION

OUTBOARD SKIN, F.S. TO R.S. (2 PER BOOSTER)

SPAN STA.	t_s	C (IN.)	MAT'L. 7075-T73
6	.15	74	
67	.13	66	
163	.08	53½	
244	.04	43	
271	.04	39	

$2(67-6)/6\,[.15(74)+.13(66)+(.15+.13)(74+66)].101 = 120.9$
$2(163-67)/6\,[.13(66)+.08(53\tfrac{1}{2})+(.13+.08)(66+53\tfrac{1}{2})].101 = 122.7$
$2(244-163)/6\,[.08(53\tfrac{1}{2})+.04(43)+(.08+.04)(53\tfrac{1}{2}+43)].101 = 47.9$
$2(271-244)/6\,[.04(43)+.04(39)+(.04+.04)(43+39)].101 = 8.9$

TOTAL WEIGHT = 300.4 LB. WT/FIN = 150.2 LB

INBOARD SKIN, F.S. TO R.S. (2 PER BOOSTER)

SPAN STA.	t_s	C (IN.)	MAT'L. 7075-T73
11	.18	74	
67	.15	66	
163	.10	53½	
244	.05	43	
271	.05	39	

$2(67-11)/6\,[.18(74)+.15(66)+(.18+.15)(74+66)].101 = 130.9$
$2(163-67)/6\,[.15(66)+.10(53\tfrac{1}{2})+(.15+.10)(66+53\tfrac{1}{2})].101 = 145.8$
$2(244-163)/6\,[.10(53\tfrac{1}{2})+.05(43)+(.10+.05)(53\tfrac{1}{2}+43)].101 = 59.9$
$2(271-244)/6\,[.05(43)+.05(39)+(.05+.05)(43+39)].101 = 11.2$

TOTAL WEIGHT = 347.8 LB., WT/FIN = 173.9 LB

OUTB'D. AND INB'D. SKIN, L.E.S. TO F.S. (2 EA. PER BOOSTER)

SPAN STA.	② (IN.)	C (IN.)	MAT'L. 7075-T73
7	.08	44	
67	.08/.06	39	
163	.05	32	
244	.05/.04	25½	
271	.04	23½	

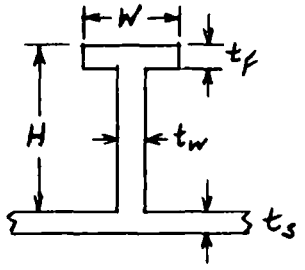
OUTB'D. AND INB'D SKIN, L,E,S. TO F.S. (CONT'D.)

$4(67-7)/6\,[.08(44)+.08(39)+(.08+.08)(44+39)].101 =$ 80.5
$4(163-67)/6\,[.06(39)+.05(32)+(.06+.05)(39+32)].101 =$ 76.0
$4(244-163)/6\,[.05(32)+.05(25\frac{1}{2})+(.05+.05)(32+25\frac{1}{2})].101 =$ 47.0
$4(271-244)/6\,[.04(25\frac{1}{2})+.04(23\frac{1}{2})+(.04+.04)(25\frac{1}{2}+23\frac{1}{2})].101 =$ 10.7

TOTAL WEIGHT = 214.2 LB., WT/FIN = 107.1 LB

INBOARD INTEGRAL STRINGERS, F.S. TO R.S.
5 IN. SPACING. MAT'L. 7075-T73

SPAN STA.	t_f	W	t_w	H	NO. PER BOOSTER	UNIT AREA
11	.300	1.0	.25	1.5	28	.600
38	.265	1.0	.217	1.4	26	.511
76	.230	1.0	.185	1.25	24	.419
114	.195	.85	.153	1.1	22	.304
152	.160	.7	.12	.95	20	.207
190	.125	.6	.10	.8	18	.143
228	.090	.5	.08	.65	16	.090
266	.055	.4	.06	.5	14	.049
271	.050	.4	.05	.5		.043



$28(38-11)/3\,[.600+.511+\sqrt{.600(.511)}].101 =$ 42.4
$26(76-38)/3\,[.511+.419+\sqrt{.511(.419)}].101 =$ 46.3
$24(114-76)/3\,[.419+.304+\sqrt{.419(.304)}].101 =$ 33.2
$22(152-114)/3\,[.304+.207+\sqrt{.304(.207)}].101 =$ 21.4
$20(190-152)/3\,[.207+.143+\sqrt{.207(.143)}].101 =$ 13.4
$18(228-190)/3\,[.143+.090+\sqrt{.143(.090)}].101 =$ 8.0
$16(266-228)/3\,[.090+.049+\sqrt{.090(.049)}].101 =$ 4.2
$14(271-266)/3\,[.049+.043+\sqrt{.049(.043)}].101 =$ 0.3

TOTAL WEIGHT = 169.2 LB., WT/FIN = 84.6 LB

OUTBOARD INTEGRAL STRINGERS, F.S. TO R.S.
5 IN. SPACING MAT'L. 7075-T73

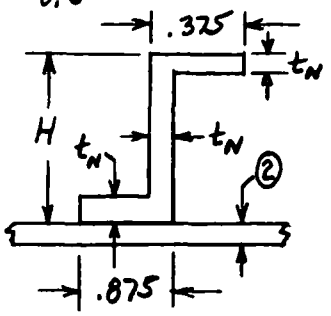
SPAN STA.	t_F	W	t_W	H	NO. PER BOOSTER	UNIT AREA
6	.120	.4	.10	1.5	28	.186
38	.120	.4	.10	1.4	26	.176
76	.120	.4	.10	1.25	24	.161
114	.110	.4	.09	1.1	22	.133
152	.100	.4	.08	.95	20	.108
190	.081	.35	.067	.8	18	.077
228	.062	.3	.054	.65	16	.050
266	.043	.25	.041	.5	14	.030
271	.040	.25	.04	.5		.028

$28(38-6)/3\,[.186+.176+\sqrt{.186(.176)}\,]\,.101 = 16.4$
$26(76-38)/3\,[.176+.161+\sqrt{.176(.161)}\,]\,.101 = 16.8$
$24(114-76)/3\,[.161+.133+\sqrt{.161(.133)}\,]\,.101 = 13.5$
$22(152-114)/3\,[.133+.108+\sqrt{.133(.108)}\,]\,.101 = 10.2$
$20(190-152)/3\,[.108+.077+\sqrt{.108(.077)}\,]\,.101 = 7.1$
$18(228-190)/3\,[.077+.050+\sqrt{.077(.050)}\,]\,.101 = 4.4$
$16(266-228)/3\,[.050+.030+\sqrt{.050(.030)}\,]\,.101 = 2.4$
$14(271-266)/3\,[.030+.028+\sqrt{.030(.028)}\,]\,.101 = 0.2$

TOTAL WEIGHT = 71.0 LB, $WT/_{FIN}$ = 35.5 LB

OUTB'D, AND INB'D. STRINGERS, L.E.S. TO F.S.
8 IN. SPACING. MAT'L. 7075-T73

SPAN STA.	t_N	H	NO. PER BOOSTER	UNIT AREA
7	.07	1.5	20	.183
51	.07	1.3	16	.169
154	.05	1.0	12	.108
257	.05	0.5	8	.083
271	.04	0.5		.067



2.2-20

OUTB'D. AND INB'D. STRINGERS, L.E.S. TO F.S. (CONT'D.)

$20(51-7)/3\left[.183+.169+\sqrt{.183(.169)}\right].101 = 15.6$
$16(154-51)/3\left[.169+.108+\sqrt{.169(.108)}\right].101 = 22.9$
$12(257-154)/3\left[.108+.083+\sqrt{.108(.083)}\right].101 = 11.9$
$8(271-257)/3\left[.083+.067+\sqrt{.083(.067)}\right].101 = 0.8$

TOTAL WEIGHT = 51.2 LB., WT/FIN = 25.6 LB

LEADING EDGE SPAR WEB (2 PER BOOSTER)

SPAN STA.	①	DEPTH	LENGTH	MAT'L. 7075-T73
5	.08	11.0		
			63	(IN.)
67	.08/.06	9.35		
			97.5	
163	.05	6.85		
			82	
244	.05/.04	4.75		
			32.5	
276	.04	3.9		

$2(63)/6\left[.08(11.0)+.08(9.35)+(.08+.08)(11.0+9.35\right].101 = 10.4$
$2(97.5)/6\left[.06(9.35)+.05(6.85)+(.06+.05)(9.35+6.85)\right].101 = 8.5$
$2(82)/6\left[.05(6.85)+.05(4.75)+(.05+.05)(6.85+4.75)\right].101 = 4.7$
$2(32.5)/6\left[.04(4.75)+.04(3.9)+(.04+.04)(4.75+3.9)\right].101 = 1.1$

TOTAL WEIGHT = 25.0 LB., WT/FIN = 12.5 LB

FRONT SPAR WEB (2 PER BOOSTER)

SPAN STA.	③	DEPTH	LENGTH (IN.)	MAT'L. 7075-T73
7½	.10	19.8		
			59.5	
67	.10/.06	17.9		
			96.5	
163	.05	13.3		
			81	
244	.05/.04	9.9		
			27	
271	.04	8.8		

$2(59.5)/6\left[.10(19.8)+.10(17.9)+(.10+.10)(19.8+17.9)\right].101 = 22.7$
$2(96.5)/6\left[.06(17.9)+.05(13.3)+(.06+.05)(17.9+13.3)\right].101 = 16.8$
$2(81)/6\left[.05(13.3)+.05(9.9)+(.05+.05)(13.3+9.9)\right].101 = 9.5$
$2(27)/6\left[.04(9.9)+.04(8.8)+(.04+.04)(9.9+8.8)\right].101 = 2.0$

TOTAL WEIGHT = 51.0 LB., WT/FIN = 25.5 LB

REAR SPAR WEB (2 PER BOOSTER)

SPAN STA.	④	DEPTH	LENGTH (IN.) MAT'L. 7075-T73
9	.15	21.7	
67	.15/.10	19.1	58
163	.08/.06	14.7	96.5
244	.05/.04	11.0	81.5
271	.04	9.8	27

$2(58)/6[.15(21.7)+.15(19.1)+(.15+.15)(21.7+19.1)].101 = 35.9$
$2(96.5)/6[.10(19.1)+.08(14.7)+(.10+.08)(19.1+14.7)].101 = 30.0$
$2(81.5)/6[.06(14.7)+.05(11.0)+(.06+.05)(14.7+11.0)].101 = 11.7$
$2(27)/6[.04(11.0)+.04(9.8)+(.04+.04)(11.0+9.8)].101 = 2.3$

TOTAL WEIGHT = 79.9 LB., WT/FIN = 39.9 LB

RIB WEBS, F.S. TO R.S. (2 EA. PER BOOSTER)

SPAN STA.	③	WIDTH	AVG. DEPTH (IN.) MAT'L. 7075-T73
9	.10	74	21.7
52	.06	68	19.8
82	.06	64	18.4
163	.05	53.5	14.7
244	.05	43	11.0
271	.04	39	9.8

$2(.10)74(21.7).101 = 32.4$
$2(.06)68(19.8).101 = 16.3$
$2(.06)64(18.4).101 = 14.3$
$2(.05)53.5(14.7).101 = 7.9$
$2(.05)43(11.0).101 = 4.8$
$2(.04)39(9.8).101 = 3.1$

TOTAL WEIGHT = 78.80 LB., WT/FIN = 39.4 LB

RIB WEBS, L.E.S. TO F.S. (2 EA. PER BOOSTER)

SPAN STA.	①	WIDTH	AVG. DEPTH (IN.) MAT'L. 7075-T73
7	.08	44	15.4
67	.05	39.5	13.3
163	.04	32	10.1
244	.04	25.5	7.3
271	.04	23.5	6.4

RIB WEBS, L.E.S. TO F.S. (CONT'D.)

2(.08) 44 (15.4).101 = 11.0
2(.05) 39.5 (13.3).101 = 5.3
2(.04) 32 (10.1).101 = 2.6
2(.04) 25.5 (7.3).101 = 1.5
2(.04) 23.5 (6.4).101 = 1.2

TOTAL WEIGHT = 21.6 LB., WT/FIN = 10.8 LB

TORQUE BOX

WING INTERSECTION COVER SKIN BEEF-UP

$(2.8 \times .75 + 1.6 \times .25 + .2 \times 5.1) = 3.27\ in^2$

$V = 75 \times 3.27 = 245\ in^3$, $WT = .101 \times 245 = 25\ LB$

VENTRAL FIN INTERSECTION COVER SKIN BEEF-UP

$(2.1 \times .8 + .5 \times .3 + 4.5 \times .25) = 2.95\ in^2$

$V = 75 \times 2.95 = 221\ in^3$

$WT = .101 \times 221 = 23\ LB$

RIBS

ROOT CLOSING RIB

WEB $21.7 \times 1.1 \times 74 = 161\ in^3$

CAPS $(2.1 \times .35 + .9 \times 2.7) \times 2 \times 74 = 269$

STIFFENERS $21 \times 1.9 \times .125 \times \frac{74}{9} = 53$

$WT = 483 \times .101 = 49\ LB$

CAPS

STA 52: $V = 2 \times 68 \times .075 \times 3.5 = 36\ in^3$

STA 82: $V = 2 \times 64 \times .025 \times 3.5 = 34\ in^3$

STA 163: $V = 2 \times 53.5 \times .06 \times 3.5 = 22\ in^3$

STA 244: $V = 2 \times 43 \times .06 \times 3.5 = 18\ in^3$

STA 271: $V = 2 \times 39 \times .05 \times 3.5 = 14\ in^3$

$\Sigma V = 124\ in^3$, $WT = .101 \times 124 = 13\ LB$

WEB STIFFENERS

STA 52: $V = 2.5 \times 19.8 \times \frac{68}{8} \times .07 = 29\ in^3$

STA 82: $V = 2.5 \times 18.4 \times \frac{64}{8} \times .07 = 26\ in^3$

STA 163: $V = 2.5 \times 14.7 \times \frac{53.5}{8} \times .063 = 15\ in^3$

TORQUE BOX ~ INTERSECTION PROVISIONS

½ Y FITTING

$A = 2.95\ in^2$

$V = 2.95 \times 94 = 277\ in^3$

INTERSECTION CLOSING RIB

WEB $13.1 \times .3 + 6.3 \times .5 = 7.08\ in^3$

CAP $1.8 \times .35 + 2.1 \times .25 + 2.0 \times .5 = 2.16\ in^3$

STIFFENERS

$(10 \times 2.0 \times .25 + 2.3 \times 7 \times .25) \div 7 = 1.29\ in^3$

$V = 94 \times (7.08 + 2.16 + 1.29) = 990\ in^3$

$\Sigma V = 990 + 277 = 1267\ in^3$

$WT = 128\ LB$

TORQUE BOX

FORMERS

STA 9 TO 52;

WEB. $V = 72 \times 21 \times .04 =$ 61 in^3

WEB STIFF.; $V = \frac{72}{8} \times 21 \times 2 \times .05 =$ 19 in^3

CAPS: $V = 72 \times 2 \times 3 \times .05 =$ 22

102 in^3

STA 82 TO 163.

WEB: $V = 58 \times 16.6 \times .04 =$ 39 in^3

WEB STIFF $V = \frac{58}{8} \times 16.6 \times 2.0 \times .05 =$ 12 in^3

CAPS $V = 2 \times 58 \times 3 \times .05 =$ 17

68

X 2

136 in^3

STA 163 TO 249

WEB. $V = 50 \times 12.9 \times .04 =$ 26

WEB STIFF. $V = \frac{50}{8} \times 12.9 \times 2.0 \times .05 =$ 8

CAPS $V = 2 \times 50 \times 3.0 \times .05 =$ 15

49 in^3

X =

98 in^3

$\Sigma V = 102 + 136 + 98 = 336\ in^3$

$Wt = 336 \times .101 = 34$ LB

FORWARD SPAR ~ WEB STIFFENERS

STA 7½ TO 67: $V = \frac{59.5}{8} \times 2.5 \times .125 \times 16.0 =$ 44 in^3

STA 67 TO 163 $V = \frac{96.5}{8} \times 15.6 \times 2.5 \times .07 =$ 33 in^3

STA 163 TO 249 $V = \frac{81}{8} \times 11.6 \times 2.5 \times .063 =$ 19 in^3

STA 249 TO 271 $V = \frac{27}{8} \times 9.9 \times 2.5 \times .05 =$ 4 in^3

$\Sigma V = 100\ in^3$, $Wt = .101 \times 100 = 10$ LB

TORQUE BOX

FRONT SPAR (CONT)

CAPS

STA 7½ TO 67

$V = 59.5 \times 4.0 \times .125 = 30 \text{ in}^3$

STA 67 TO 163

$V = 96.5 \times 4.0 \times .07 = 27 \text{ in}^3$

STA 163 TO 244

$V = 81 \times 4.0 \times .063 = 20 \text{ in}^3$

STA 249 TO 271

$V = 27 \times 4.0 \times .05 = 5 \text{ in}^3$

$\Sigma V = 84 \times 2 = 168 \text{ in}^3$, $WT = 168 \times .101 = 17 \text{ LB}$

REAR SPAR

WEB STIFFENERS

STA 9 TO 67

$V = \frac{58}{8} \times 20.4 \times 2.5 \times .16 = 59 \text{ in}^3$

STA 67 TO 163

$V = \frac{96.5}{8} \times 16.9 \times 2.5 \times .10 = 51$

STA 163 TO 249

$V = \frac{81.5}{8} \times 12.4 \times .063 \times 2.5 = 20$

STA 249 TO 271

$V = \frac{27}{8} \times 10.4 \times 2.5 \times .05 = 4$

$\Sigma V = 134 \text{ in}^3$, $WT = 134 \times .101 = 14 \text{ LB}$

2.2-27

TORQUE BOX

REAR SPAR (CONT.)

CAPS

STA 9 TO 67 $V = 58 \times 4.0 \times .16 = 37.1^3$

STA 67 TO 163 $V = 96.5 \times 4.0 \times .15 = 58.1^3$

STA 163 TO 244 $V = 81.5 \times 4.0 \times .12 = 39.1^3$

STA 244 TO 271; $V = 27 \times 4.0 \times .10 = 11 in^3$

$2V = 2 \times 145 = 290.1^3$

$WT = .101 \times 290 = 29$ LB

TRAILING EDGE

GAP COVER

WING GAP COVER: $\frac{148}{660} = .224 \frac{LB}{IN}$

FIN: $265 \times .224 = 60$ LB

RUDDER TO BASE STRUCTURE

$W = 54$ LB

HINGE FITTINGS

$WT = 80$

GAP COVER	60
RUDDER BASE STRUCTURE	54
HINGE FITTINGS	80
	194
ATTACH, SPLICE, JOINT	19
	213 LB

RUDDER

SKIN	290		
STIFF (COVER PANEL)	15	305	
HINGE RIBS	137		
INTERMEDIATE RIBS	89	226	
FORMERS	82		
FRONT SPAR	55		
AFT SPAR	50	105	
T.E. MEMBER	F/		
ACTUATOR & HINGE FITTINGS	95		
[illegible] 15%	138		

RUDDER

SKIN $WT = \frac{67+128}{2} \times 248 \times .06 \times 2 \times .101 = 290$ LB

STIFF

WT $16 \times 25.0 \times 3.6 \times .08 \times .101 \times 2$

HINGE RIBS

#1. WEB	$18 \times 90 \times .125$	= 202
STIF	$\frac{90}{6} \times 18 \times$ (illegible)	33
CAPS	$90 \times 2 \times 5.0 \times .15$	= 135
ENDS	$18 \times 2 \times 5.0 \times .15$	27
		452

$WT = .101 \times 452 = 46$ LB

#2: WEB	$17 \times 84 \times .125$	= 179
STIFF	$\frac{84}{6} \times 17 \times$ (illegible)	= 77
CAPS	$84 \times 2 \times 5.0 \times .15$	= 126
ENDS	$17 \times 2 \times 5.0 \times .15$	= 25
		407. IN^3

$WT = 407 \times .101 = 41$ LB

#3 WEB	$13 \times 72 \times .125$	= 117
STIFF	$\frac{72}{6} \times 15 \times .32$	= 51
CAPS	$72 \times 2 \times 5.0 \times .15$	= 108
ENDS	$13 \times 2 \times 5.0 \times .15$	= 20
		296 $\times .101$ 30 LB

#4 WEB	$10 \times 56 \times .125$	= 70
STIFF	$\frac{56}{2} \times 10 \times .375$	= 30
CAPS	$56 \times 2 \times$ (illegible) $\times .15$	= 89
ENDS	$10 \times 2 \times$ (illegible) $\times .15$	= 15
		199 $\times .101 = 20$ LB

RUDDER (CONT)

RIBS ~ INTERMEDIATE

WEBS $(80 \times 16 + 76 \times 19 + 65 \times 11 + 60 \times 12) \times .06 = 225 \text{ in}^3$

CAPS $2 \times 4.0 \times .08 (80 + 76 + 65 + 60) = 180$

STIFF $2.0 \times .08 \times \frac{1}{8} (14.0)(80 + 76 + 65 + 60) = 80$

ENDS $3.0 \times .08 \times 2 \times (16 + 19 + 11 + 12) = 25$

$WT = .101 \times 510 = 51 \text{ LB}$

FORMERS

CAPS $2.0 \times .05 \times 2 \times (2 \times 86 + 2 \times 82 + 2 \times 76 + 2 \times 73 + 2 \times 67 + 2 \times 58 + 2 \times 57 + 2 \times 52) = 220 \text{ in}^3$

WEBS $.04 \times (2 \times 86 \times 17 + 2 \times 82 \times 16 + 2 \times 76 \times 15 + 2 \times 73 \times 14 + 2 \times 67 \times 12 + 2 \times 58 \times 11 + 2 \times 57 \times 10 + 2 \times 52 \times 8) = 589 \times .7$ (HOLES) $= 412 \text{ in}^3$

STIFF: $.05 \times \frac{1}{8} \times (86 \times 17 + 82 \times 16 + 76 \times 15 + 73 \times 14 + 67 \times 12 + 58 \times 11 + 57 \times 10 + 8 \times 52) \times 2.0 \times 2 = 189$

ENDS $2 \times 2.5 \times .05 (17 + 16 + 15 + 14 + 12 + 11 + 10 + 8) \times 2 = \ldots$

$\Sigma V = 816, \quad WT = .101 \times 816 = 82 \text{ lb}$

CLOSING RIB

WEB $17 \times 95 \times .100 = 162$

STIFF $17 \times \frac{95}{8} \times .125 \times 2 = 50$

CAPS $2 \times 95 \times .125 \times 30 = 71$

END $17 \times 2 \times 3.0 \times .125 = 13$

$WT = .101 \times 296 = 30 \text{ LB}$

TIP RIB

WEB $9 \times 50 \times .08 = 36$

STIFF $9 \times \frac{50}{8} \times 2.0 \times .1 = 11$

CAPS $2 \times 50 \times 3.0 \times .1 = 30$

END $9 \times 2 \times 3.0 \times .1 = 5$

$WT = .101 \times 82 = 8$

RUDDER (CONT)

FRONT SPAR

WEB $V = 116 \times 18 \times .12 + 12.5 \times .128 \times 1 = 160\ in^3$

CAPS $V = .5 \times 52 + 84 \times 1.05 + 108 \times 1.05 + 6 \times .5 = 231\ in^3$

STIFF $V = 15 \times 2 \times .11 \times \frac{249}{8} = 101\ in^3$

ATTACH, SPLICES, JOINTS $50\ in^3$

$542\ in^3$

$WT = .101 \times 542 = 55\ LB$

REAR SPAR

WEB: $V = 7.0 \times 120 \times .12 + 4 \times 130 \times .1 = 153\ in^3$

CAPS $V = .5 \times 52 + 84 \times 1.05 + 108 \times .105 + 10 \times .5 = 233\ in^3$

STIFF $V = \frac{250}{5} \times 2.0 \times 5.5 \times .11 = 61$

ATTACH, SPLICES, JOINTS 45

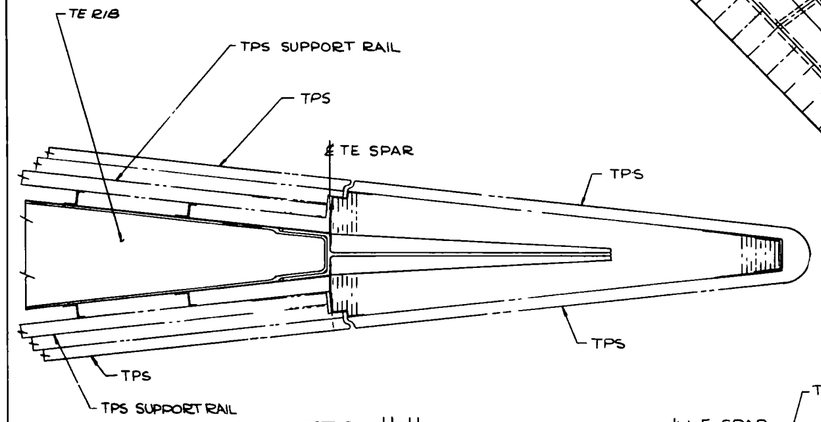
$492\ in^3$

$WT = 492 \times .101 = 50\ LB$

TRAILING EDGE MEMBER

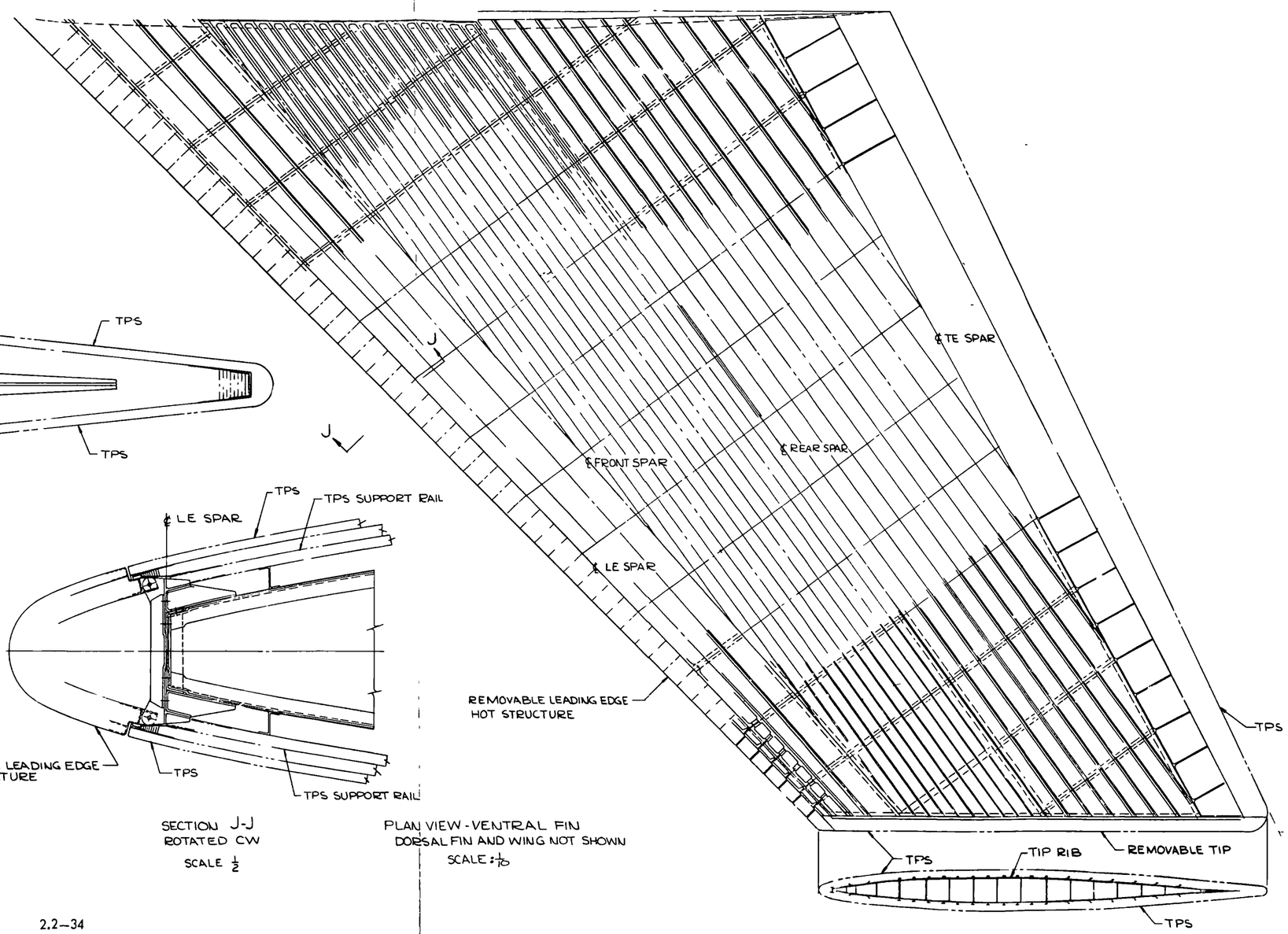
$V = 10.0 \times .2 \times 255 + 1.75 \times .3 \times 28 \times .2 + 4.0 \times 255 \times .125 + 1.7 \times 255 \times .15 = 801\ in^3$

$WT = 801 \times .101 = 81\ LB$



SECTION H-H
ROTATED CW
SCALE ½

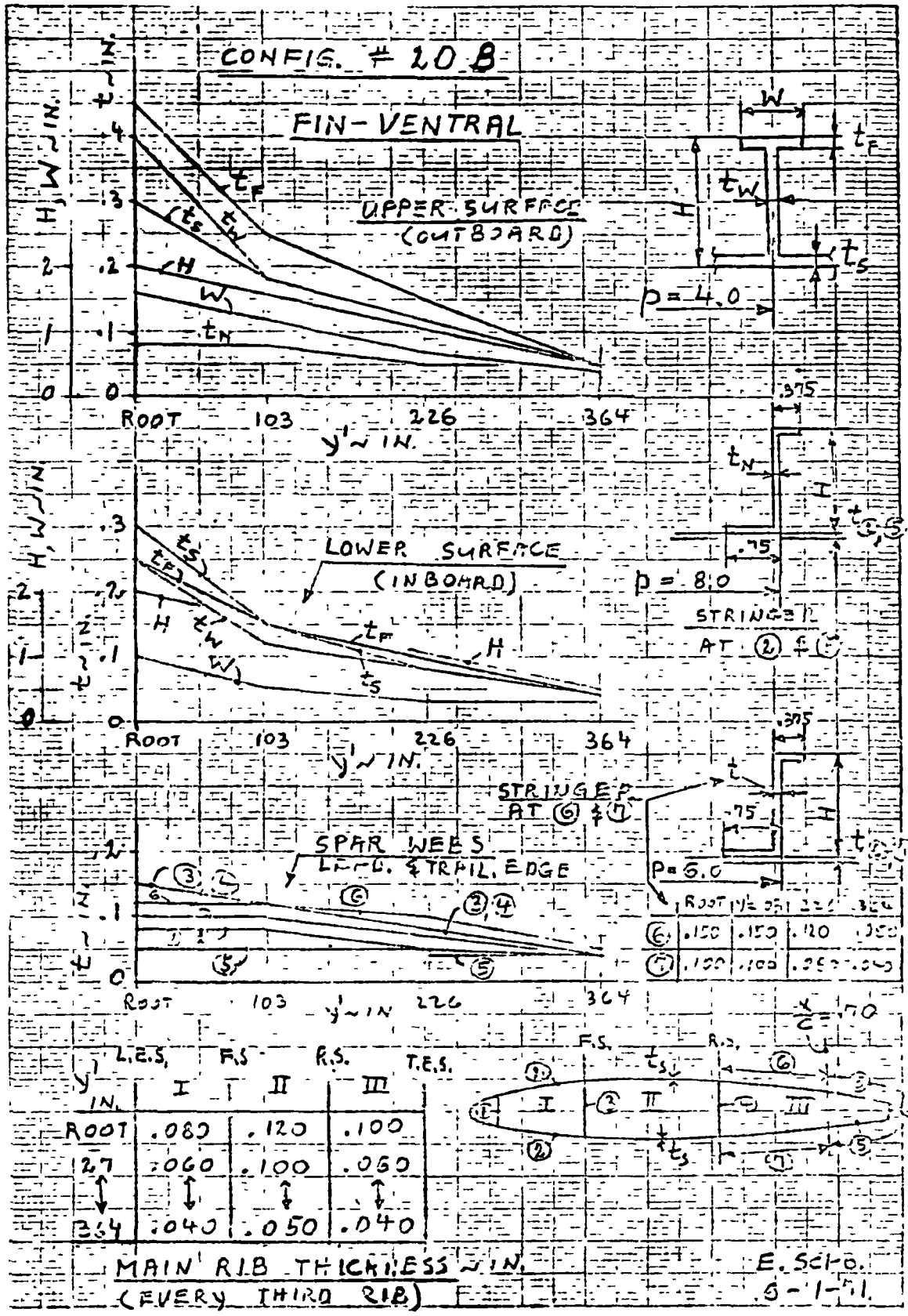
SECTION J-J
ROTATED CW
SCALE ½



PLAN VIEW - VENTRAL FIN
DORSAL FIN AND WING NOT SHOWN
SCALE: 1/10

MARTIN MARIETTA CORPORATION
FIN STRUCTURE ASSEMBLY
CONFIGURATION 20B
J 04236 899A201064 1
SHEET 2 OF 4

		WEIGHT (LB) PER BOOSTER
VENTRAL FIN	[2,865]	[5,730]
LEADING EDGE	(577)	
NOSE	308	
COVER	150	
RIBS	34	
FORMERS	15	
SPAR	45	
ATTACH, JOINTS, SPLICE	25	
TORQUE BOX	(1,655)	
COVERS	950	
SPARS	195	
RIBS	143	
FORMERS	48	
WING ATTACH PROVISIONS	169	
ATTACH, SPLICES, JOINTS	150	
TRAILING EDGE	(633)	
COVERS	396	
SPAR	73	
RIBS	63	
FORMERS	41	
ATTACH, SPLICE, JOINT	60	



y' IN.	I	II	III
ROOT	.080	.120	.100
27	.060	.100	.060
↕	↕	↕	↕
364	.040	.050	.040

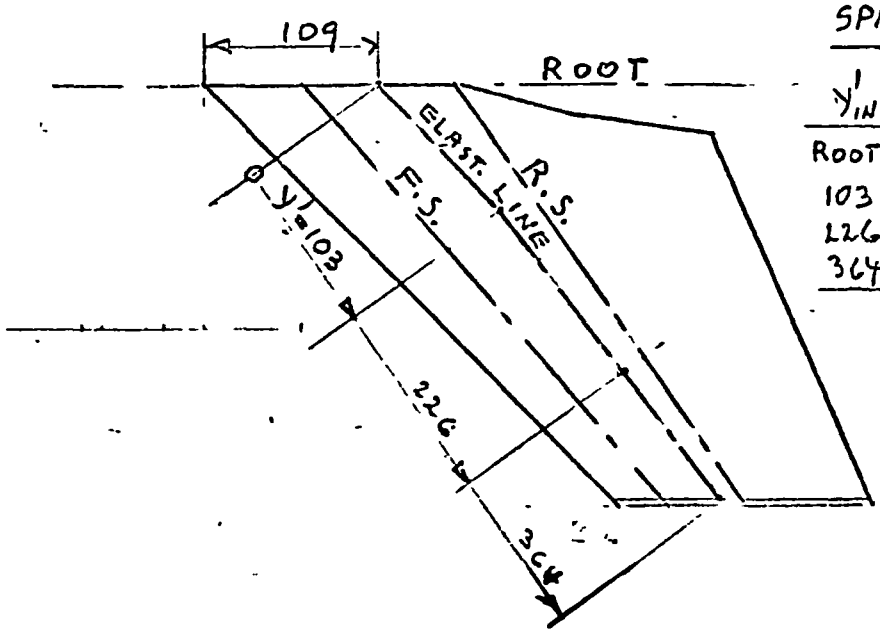
SUBJECT CONFIG. #20A
FIN-VENTRAL
SUMMARY OF THICKN. ETC.

UPPER SURFACE (OUTBOARD)

y' IN	t_F IN.	t_W IN.	t_s IN.	$t_{②}$ IN.	$t_{⑥}$ IN.	$t_{⑤}$ IN.	H IN.	W IN.
ROOT	.450	.400	.300	.080	.120	.050	2.0	1.60
103	.250	.180	.180	.080	.120	.050		1.20
226	.150	.120	.120	.050	.100	.050 .040		.70
364	.050	.050	.050	.040	.050	.040	.50	.40
TIP	/	/	.040	.040	.040	.040		

LOWER SURFACE (INBOARD)

y' IN.	t_F IN.	t_W IN.	t_s IN.	$t_{①}$ IN.	$t_{⑥}$ IN	$t_{⑤}$ IN	H IN	W IN.
ROOT	.250	.250	.300	.080	.100	.050	2.0	1.0
103	.150	.120	.150	.080	.100	.050		.50
226	.098	.080	.080	.050	.072	.050 .040		.30
364	.040	.040	.040	.040	.040	.040	.50	.30
TIP	/		.040	.040	.040	.040	/	/



SPAR THICKN. IN

y' IN	L.E. ①	F.S. ③	R.S ④	T.E. ⑤
ROOT	.080	.150	.150	.050
103	.080	.120	.120	.050
226	.050	.080	.080	.050
364	.040	.040	.040	.050

VENTRAL FIN

LEADING EDGE SUMMARY

COVER SKIN	119 LB
COVER STRINGERS	31
RIBS	34
FORMERS	15
L.E SPAR	45
ATTACH, JOINTS, SPLICES	25
NOSE (HOT STRUCTURE - COL.)	308
TOTAL FOR 1	577 LB

LEADING EDGE SPAR

WEB STIFFENERS

STA -45 TO 103

$V = \frac{148}{8} \times 9.3 \times 2.5 \times .09 = 39 \text{ in}^3$

STA 103 TO 226

$V = \frac{123}{8} \times 58 \times 2.5 \times .063 = 14 \text{ in}^3$

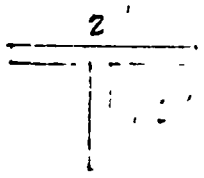
STA 226 TO [illegible]

$V = \frac{101}{8} \times 4.6 \times 2.5 \times .06 = 8 \text{ in}^3$

$2V = 39 + 14 + 8 = 61 \text{ in}^3$

$Wt = 61 \times .101 = 6 \text{ LB}$

CAP



STA [illegible] $V = 3.5 \times 149 \times 2 \times .09 = 93 \text{ in}^3$

STA 103 TO [illegible] $V = 123 \times 3.5 \times [illegible] .075 = 65 \text{ in}^3$

STA [illegible] TO 32[illegible] $V = 101 \times 3.5 \times 2 \times .06 = 42 \text{ in}^3$

$2V = [illegible] + 65 + 42 = 200 \text{ in}^3$

$Wt = .101 \times 200 = 20 \text{ LB}$

TOTAL SPAR WT = 18 + 20 + 6 = 45 LB

L.E. -FORMERS

L.E. TO FRONT SPAR

WEBS

USE AVG DIMENSIONS OF RIB WEBS

SWEPT STA 27 TO 92

$W_{AVG} = 28$ in., $D_{AVG} = 14.0$ in.

$A = 28 \times 14.0 = 392$ in^2

$t = .04$

$\Sigma V = .04 \times 392 = 16$ in$^3 \times 2 = 32$ in^3

STA 92 TO 172

$W_{AVG} = 25$ in, $D_{AVG} = 12.0$ in.

$\Sigma V = 25 \times 12.0 \times .04 \times 2 = 24$ in^3

STA 172 TO 253

$W_{AVG} = 21.5$ in, $D_{AVG} = 10.2$ in.

$\Sigma V = 21.5 \times 10.2 \times .04 \times 2 = 18$ in^3

STA 253 TO 306

$W_{AVG} = 19$ in, $D_{AVG} = 8.5$ in.

$\Sigma V = 19 \times 8.5 \times .04 \times 1 = 7$ in^3

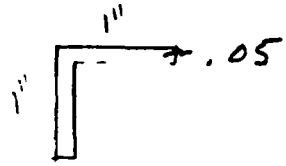
$\Sigma V = 32 + 24 + 18 + 7 = 81$ in^3

$Wt = .101 \times 81 = 8$ LB

TOTAL FORMER WT = $8 + 4 + 3 =$ 15 LB

RIB-FORMERS L.E. TO FRONT STAR

WEB STIFFENERS



STA 20 TO 92

$H = 13.7$, $A = 2.0 \times .05 = .10\ in^2$

$V = 13.7 \times .1 \times 4 \times 2 = 11\ in^3$

STA 92 TO 172

$H = 12.0\ in.$, $A = .1\ in^2$

$V = 4 \times 12.0 \times .1 \times 2 = 10\ in^3$

STA 172 TO 253

$H = 17.3\ in$, $A = .1\ in^2$

$V = 3 \times 17.3 \times .1 \times 2 = 10\ in^3$

STA 253 TO 306

$H = 14.8\ in.$, $A = .1$

$V = 3 \times 14.8 \times .1 \times 1 = 5\ in^3$

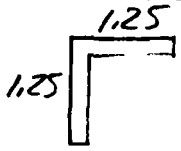
$\Sigma V = 11 + 10 + 10 + 5 = 36$

$Wt = .101 \times 36 = 4\ LB$

RIBS

L.E. TO FRONT SPAR

WEB STIFFENERS



SPACING = 8 in.

ROOT: $V = \frac{46}{8} \times 15.8 \times .09 \times 2.5 = 20 \text{ in}^3$

STA -16: $V = \frac{31}{8} \times 15.4 \times .08 \times 2.5 = 12 \text{ in}^3$

STA 27: $V = \frac{29}{8} \times 14.2 \times .07 \times 2.5 = 9 \text{ in}^3$

STA 92: $V = \frac{27}{8} \times 12.9 \quad 063 \times 2.5 = 7 \text{ in}^3$

STA 172: $V = \frac{23}{8} \times 11.0 \times .06 \times 2.5 = 5 \text{ in}^3$

STA 253: $V = \frac{20}{8} \times 9.1 \times .05 \times 2.5 = 3 \text{ in}^3$

STA 306: $V = \frac{18}{8} \times 7.8 \times .05 \times 2.5 = 2 \text{ in}^3$

TIP $V = \frac{23}{8} \times 6.8 \times .05 \times 2.5 = 2 \text{ in}^3$

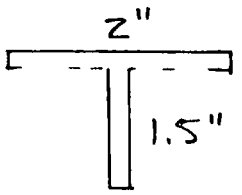
$\Sigma V = 60 \text{ in}^3$

$W = 60 \times .101 = 6 \text{ LB}$

RIBS

L.E. TO FRONT SPAR

CAPS



ROOT: $V = 46 \times 2 \times 3.5 \times .10 = 32 \text{ in}^3$

STA 56 $V = 31 \times 2 \times 3.5 \times .08 = 17 \text{ in}^3$

STA 27 $V = 29 \times 2 \times 3.5 \times .07 = 14 \text{ in}^3$

STA 92 $V = 27 \times 2 \times 3.5 \times .063 = 12 \text{ in}^3$

STA 172 $V = 23 \times 2 \times 3.5 \times .063 = 10 \text{ in}^3$

STA 253 $V = 20 \times 2 \times 3.5 \times .05 = 7 \text{ in}^3$

STA 306 $V = 16 \times 2 \times 3.5 \times .05 = 6 \text{ in}^3$

TIP $V = 23 \times 2 \times 3.5 \times .05 = 8 \text{ in}^3$

$\Sigma V = 32 + 17 + 14 + 12 + 10 + 7 + 6 + 8 = 106 \text{ in}^3$

$W_{\Sigma} = .101 \times 106 = 11 \text{ LB}$

TOTAL RIB WT = $11 + 17 + 6 = \underline{\underline{34 \text{ LB}}}$

VERTICAL FIN

LEAD = EDGE

LEADING EDGE SPAR WEB (2 PER BOOSTER)

SWEPT STA.	①	DEPTH	LENGTH (IN.) MAT'L. 7075-T73
-45	.08	10.8	149.5
103	.08	7.9	124.5
226	.05	5.5	102
327	.04	3.6	

$2(149.5)/6\,[.08(10.8)+.08(7.9)+(.08+.08)(10.8+7.9)].101 = 22.6$
$2(124.5)/6\,[.08(7.9)+.05(5.5)+(.08+.05)(7.9+3.6)].101 = 10.$
$2(102)/6\,[.05(5.5)+.04(3.6)+(.05+.04)(5.5+3.6)].101 = 4.$

TOTAL WEIGHT = 36.9 LB $\quad WT_{\frac{VERT}{FIN}} = 18$ LB

RIB WEBS, L.E.S. TO F.S. (2 EA. PER BOOSTER) MAIN

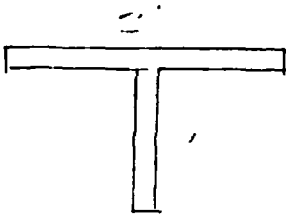
SWEPT STA.	①	WIDTH	AVG. DEPTH (IN.) MAT'L. 7075-T73
ROOT	.08	46	15.8
-16	.07	31	15.4
27	.06	29	14.4
92	.055	27	12.9
172	.05	23	11.0
253	.045	20	9.1
306	.04	18	7.8
TIP	.04	23	6.8

$2(.08)\,46\cdot 15.8\,.101 = 11.$
$2(.07)\,31\,(15.4\,.101 = 6.$
$2(.06)\,29\cdot 14.4\,.101 = 5.$
$2(.055)\,27\;12.9\,.101 = 3.9$
$2(.05)\,23\;11.0\,).101 = 2.6$
$2(.045)\,20\;9.1\,).101 = 1.7$
$2(.04)\,18\,(7.8\,.101 = 1.1$
$2(.04)\,23\,(6.8)\,.101 = 1.3$

TOTAL WEIGHT = 34.2 LB. $\quad WT_{\frac{VERT}{FIN}} = 17$ LB

RIB-FORMERS ~ L.E. TO FRONT SPAR

CAPS



$A = 3 \times .05 = .15 \text{ in}^2$

$\Sigma L = 2 \times (2 \times 28 + 2 \times 25 + 2 \times 21.3 + 2 \times 19)$

$= 187 \text{ in}$

$V = .15 \times 187 = 28 \text{ in}^3$

$WT = 28 \times .101 = 3 \text{ LB}$

OUTB'D. AND INB'D. SKIN, L.E.S. TO F.S. (2 EA. PER BOOSTER)

SWEPT STA.	②	C	(IN.)	MAT'L. 7075-T73
-30/103	.08	32/26.5		$4(326-226)/6[.05(21)+.04(17.5)+(.05+.04)(21+17.5)].101=35.1$
326/226	.04/.05	17.5/21		

$4(103+30)/6[.08(32)+.08(26.5)+(.08+.08)(32+26.5)].101 = 135.7$

$4(226-103)/6[.08(26.5)+.05(21)+(.08+.05)(26.5+21)].101 = 77.4$

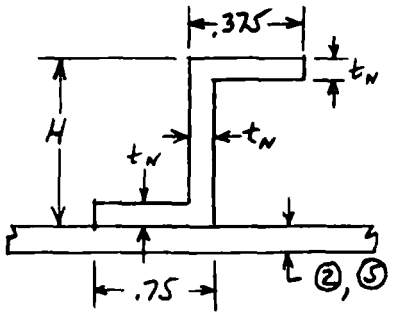
TOTAL WEIGHT = 238.2 LB.

W. " = 119 LB

VENTRAL FIN

OUTBOARD AND INBOARD STRINGERS, L.E.S. TO F.S.
8 IN. SPACING. MAT'L. 7075-T73

SWEPT STA.	t_N	H	NO. PER BOOSTER	UNIT AREA
-30	.08	2.0	12	.237
103	.08	1.5	12	.197
166	.065	1.2	8	.143
226	.05	.95	8	.099
326	.05	.5		.076



$12(103+30)/3\left[.237+.197+\sqrt{.237(.197)}\right].101 = 34.9$
$12(166-103)/3\left[.197+.143+\sqrt{.197(.143)}\right].101 = 12.9$
$8(226-166)/3\left[.143+.099+\sqrt{.143(.099)}\right].101 = 5.8$
$8(326-226)/3\left[.099+.076+\sqrt{.099(.076)}\right].101 = 7.0$

TOTAL WEIGHT = 60.6 LB.

$W/T_{\text{ONE FIN}} = 30.3$

VENTRAL FIN

TORQUE BOX

COVER SKIN ~ INBOARD	299
COVER STRINGERS ~ INBOARD	103
COVER STRINGERS ~ OUTBOARD	214
COVER SKIN ~ OUTBOARD	334
FRONT SPAR	98
REAR SPAR	97
RIBS	143
FORMERS	48
WING - VENTRAL FIN INTERSECT PROVISION	119
ATTACH., SPLICES, JOINTS	150
WING - FIN ATTACH. BOLTS, NUTS	50
	1655

VENTRAL FIN

TORQUE BOX

TOTAL COVER. WEIGHT

214 + 103 + 313 + 250 + 49 + 21 = 950 LB

FRONT SPAR WEB (2 PER BOOSTER)

SWEPT STA.	③	DEPTH	LENGTH (IN.) MAT'L. 7075-T73
-16.5	.15	19.3	353
333	.04	8.0	

2(353)/6 [.15(19.3) + .04(8.0) + (.15+.04)(19.3+8.0)].101 = 99.9
WT/FIN = 49.95 LB

REAR SPAR WEB (2 PER BOOSTER)

SWEPT STA.	④	DEPTH	LENGTH (IN.) MAT'L. 7075-T73
37	.15	20.8	325
362	.04	8.8	

2(325)/6 [.15(20.8) + .04(8.8) + (.15+.04)(20.8+8.8)].101 = 99.5 LB.
WT/FIN = 49.75 LB

TRAILING EDGE SPAR WEB (2 PER BOOSTER)

SWEPT STA.	⑤	DEPTH	LENGTH (IN.) MAT'L. 7075-T73
90.5	.08	6.8	12.5
103	.08	6.6	123.5
226	.05	4.5	167
392	.04	1.8	

2(12.5)/6 [.08(6.8) + .08(6.6 + (.08+.08)(6.8+6.6)].101 = 1.4
2(123.5)/6 [.08(6.6) + .05(4.5 + (.08+.05)(6.6+4.5)].101 = 5.
2(167)/6 [.05(4.5) + .04(1.8) + (.05+.04)(4.5+1.8)].101 = 4.

TOTAL WEIGHT = 15.4 LB.

OUTBOARD INTEGRAL STRINGERS, F.S. TO R.S. (CONT'D.)

SWEPT STA.	t_F	W	t_W	H	NO. PER BOOSTER	UNIT AREA
6.5	.45	1.6	.40	2.0	36	1.34
11.5	.44	1.6	.39	2.0	34	1.31
51.7	.34	1.42	.29	1.8	32	.906
91.9	.25	1.24	.18	1.6	30	.553
132.1	.21	1.06	.16	1.4	28	.413
172.3	.17	.88	.14	1.2	26	.294
212.5	.14	.7	.12	1.0	24	.201
252.7	.11	.61	.10	.8	22	.136
292.9	.08	.52	.08	.6	20	.083
333.1	.05	.43	.06	.5	18	.049
348	.05	.4	.05	.5		.043

$36\,(11.5-6.5)/3\,[1.34 + 1.31 + \sqrt{1.34\,(1.31)}\,].101 = 24.1$
$34\,(51.7-11.5)/3\,[1.31 + .906 + \sqrt{1.31\,(.906)}\,].101 = 152.1$
$32\,(91.9-51.7)/3\,[.906 + .553 + \sqrt{.906\,(.553)}\,].101 = 93.8$
$30\,(132.1-91.9)/3\,[.553 + .413 + \sqrt{.553\,(.413)}\,].101 = 58.6$
$28\,(172.3-132.1)/3\,[.413 + .294 + \sqrt{.413\,(.294)}\,].101 = 40.0$
$26\,(212.5-172.3)/3\,[.294 + .201 + \sqrt{.294\,(.201)}\,].101 = 26.0$
$24\,(252.7-212.5)/3\,[.201 + .136 + \sqrt{.201\,(.136)}\,].101 = 16.3$
$22\,(292.9-252.7)/3\,[.136 + .083 + \sqrt{.136\,(.083)}\,].101 = 9.7$
$20\,(333.1-292.9)/3\,[.083 + .049 + \sqrt{.083\,(.049)}\,].101 = 5.3$
$18\,(348-333.1)/3\,[.049 + .043 + \sqrt{.049\,(.043)}\,].101 = 1.2$

TOTAL WEIGHT = 427.1 LB., WT/FT = 213.5 LF

INBOARD INTEGRAL STRINGERS, F.S. TO R.S.
4 IN. SPACING. MAT'L. 7075-T73

SWEPT STA.	t_F	W	t_W	H	NO. PER BOOSTER	UNIT AREA
16	.25	1.0	.25	2.0	34	.688
51.7	.20	.75	.19	1.85	32	.464
91.9	.15	.5	.12	1.7	30	.261
132.1	.13	.44	.11	1.55	28	.213
172.3	.11	.37	.10	1.4	26	.170
212.5	.095	.3	.09	1.2	24	.128
252.7	.08	.3	.075	1.0	22	.093
292.9	.065	.3	.06	.8	20	.064
333.1	.05	.3	.045	.55	18	.038
348	.04	.3	.04	.5		.030

INBOARD INTEGRAL STRINGERS, F.S. TO R.S. (CONT'D.)

$34(51.7-16)/3\,[.688+.464+\sqrt{.688(.464)}]\,.101 = 70.2$
$32(91.9-51.7)/3\,[.464+.261+\sqrt{.464(.261)}]\,.101 = 46.5$
$30(132.1-91.9)/3\,[.261+.213+\sqrt{.261(.213)}]\,.101 = 28.8$
$28(172.3-132.1)/3\,[.213+.170+\sqrt{.213(.170)}]\,.101 = 21.7$
$26(212.5-172.3)/3\,[.170+.128+\sqrt{.170(.128)}]\,.101 = 15.7$
$24(252.7-212.5)/3\,[.128+.093+\sqrt{.128(.093)}]\,.101 = 10.7$
$22(292.9-252.7)/3\,[.093+.064+\sqrt{.093(.064)}]\,.101 = 7.0$
$20(333.1-292.9)/3\,[.064+.038+\sqrt{.064(.038)}]\,.101 = 4.1$
$18(348-333.1)/3\,[.038+.030+\sqrt{.038(.030)}]\,.101 = 0.9$

TOTAL WEIGHT = 205.6 LB., WT/FIN = 102.8 LB

VENTRAL WEIGHT SUBSTANTIATION

OUTBOARD SKIN, F.S. TO R.S. (2 PER BOOSTER)

SWEPT STA.	t_s	C	(IN.) MAT'L. 7075-T73
6.5	.30	72.5	
103	.18	63	
226	.12	50.5	
348	.05	38.5	

$2(103-6.5)/6\,[.30(72.5)+.18(63)+(.30+.18)(72.5+63)].101 = 318.8$
$2(226-103)/6\,[.18(63)+.12(50.5)+(.18+.12)(63+50.5)].101 = 213.1$
$2(348-226)/6\,[.12(50.5)+.05(38.5)+(.12+.05)(50.5+38.5)].101 = 94.9$

TOTAL WEIGHT = 626.8 LB., WT/FIN = 313.4 LB

INBOARD SKIN, F.S. TO R.S. (2 PER BOOSTER)

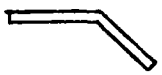
SWEPT STA.	t_s	C	(IN.) MAT'L. 7075-T73
16	.30	71.5	
103	.15	63	
226	.08	50.5	
348	.04	38.5	

$2(103-16)/6\,[.30(71.5)+.15(63)+(.30+.15)(71.5+63)].101 = 267.8$
$2(226-103)/6\,[.15(63)+.08(50.5)+(.15+.08)(63+50.5)].101 = 164.0$
$2(348-226)/6\,[.08(50.5)+.04(38.5)+(.08+.04)(50.5+38.5)].101 = 66.8$

TOTAL WEIGHT = 498.6 LB., WT/FIN = 249.3 LB

TORQUE BOX – INTERSECTION PROVISIONS

½ Y FITTING, TIE TO DORSAL FIN

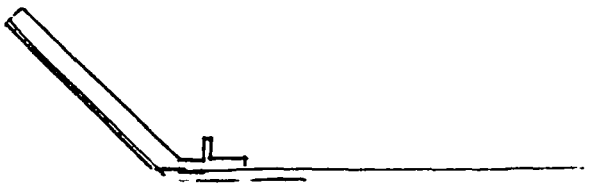


$A = 2.4 \times .25 + 4.7 \times .5 = 2.95 \text{ in}^2$

$L = 94$ in

$V = 94 \times 2.95 = 277 \text{ in}^3$

INTERSECTION CLOSURE RIB



WEB: $6.5 \times .50 + 12.4 \times .25 = 6.35 \text{ in}^2$

CAP $2.0 \times 35 + 1.5 \times .5 + 2.1 \times .25 = 1.975$

WEB STIFF. $2.0 \times 18 \times .25 \div 7 = 1.286$

9.611

$L = 94$

$V = 9.611 \times 94 = 903 \text{ in}^3$

277

1180

$\times .101$

DORSAL FIN – WING ATTACHMENTS

BOLTS, NUTS, WASHERS 50 LB

COVER BEEF-UP FOR WING-FIN ATTACH

INB'D. $(3.8 \times 1.0 + 4.1 \times .3 + .9 \times .35 - .75^2 \times .785 \times 1.0 + 2.5) \times 94 = 496$

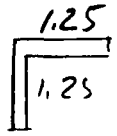
$W = .101 \times 486 = 49$ LB

OUTB'D $(2.3 \times .8 + .5 \times .4 + .1 \times 3.6 - .75^2 \times .8 \times .785 + 2.5) 94 = 212$, $W = .101 \times 212 = 21$ LB

TORQUE BOX

FRONT SPAR

WEB STIFFENERS



$N = 348.5 \div 8 = 44$

$H_{AVG} = (23.2 + 12.2) \div 2 = 17.7$ in.

$t_{Root} = .16$, $t_{TIP} = .05$

STA −16.5 TO 70.5

$V = 11 \times 17.9 \times .145 \times 2.5 = 71$ in^3

STA 70.5 TO 157

$V = 11 \times 15.1 \times .12 \times 2.5 = 50$ in^3

STA 157 TO 244

$V = 11 \times 12.3 \times .10 \times 2.5 = 34$ in^3

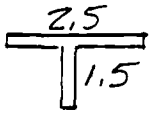
STA 244 TO [illegible]

$V = 11 \times 9.4 \times .063 \times 2.5 = 16$ in^3

$\Sigma V = 71 + 50 + 34 + 16 = 171$

$Wt = 171 \times .101 = 17$ LB

CAPS



STA −16.5 TO 70.5

$V = 87 \times 4.0 \times .15 = 52$ in^3

STA 70.5–157 $V = 87 \times 4.0 \times .125 = 43$ in^3

TORQUE BOX

FRONT SPAR

CAPS (CONT)

STA 157 TO 244

$V = 87 \times 4.0 \times .10 = 35 \text{ in}^3$

STA 2[illegible] TO 3[illegible]

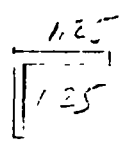
$V = 87 \times 4.0 \times .07 = 24 \text{ in}^3$

$\Sigma V = 52 + 43 + 35 + 24 = 154 \text{ in}^3$

$W_T = 2 \times 154 \times .101 = 31 \text{ LB}$

AFT SPAR

WEB STIFFENER



STA 37 - 118

$V = \frac{81}{8} \times 2.50 \times .145 \times 19.3 = 71 \text{ in}^3$

STA 118 - [illegible]

$V = \frac{81}{8} \times 2.5 \times .12 \times 16.3 = 50 \text{ in}^3$

STA 199 - 280

$V = \frac{81}{8} \times 2.5 \times .10 \times 13.3 = 34 \text{ in}^3$

STA 280 - 362

$V = \frac{82}{8} \times 2.5 \times .063 \times 10.3 = 17 \text{ in}^3$

$\Sigma V \quad 71 + 50 + 34 + 17 = 172 \text{ in}^3$

$W_T = .101 \times 172 = 17 \text{ LB}$

RIB WEBS, F.S. TO R.S (2 EA. PER BOOSTER) MAIN

SWEPT STA.	(IN.)	WIDTH	AVG. DEPTH	(IN.) MAT'L, 7075-T73
ROOT	.12	93	21.3	
27	.10	70	20.4	
92	.09	64	18.1	
172	.08	55	15.3	
253	.065	48	12.5	
333	.05	40	9.8	
TIP	.05	49	9.1	

2 (.12) 93 (21.3) .101 = 48.0
2 (.10) 70 (20.4) .101 = 28.8
2 (.09) 64 (18.1) .101 = 21.0
2 (.08) 55 (15.3) .101 = 13.6
2 (.065) 48 (12.5) .101 = 7.9
2 (.05) 40 (9.8) .101 = 4.0
2 (.05) 49 (9.1) .101 = 4.5

TOTAL WEIGHT = 127.8 LB., WT/FIN = 63.9 LB.

TOTAL RIB WT = 56+23+69 = 148 LB

TORQUE BOX

REAR SPAR (CONT)

CAPS

STA 37-118 $V = 81 \times 4.0 \times .15 = 49 in^3$

STA 118-199 $V = 81 \times 4.0 \times .125 = 41 in^3$

STA 199-280

$V = 81 \times 4.0 \times .10 = 32 in^3$

STA 280-320

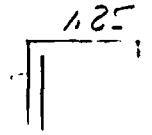
$V = 82 \times 4.0 \times .08 = 26 in^3$

$\Sigma V = 49 + 41 + 32 + 26 = 148 in^3$

$WT = 2 \times .101 \times 148 = 30 LB$

RIBS

WEB STATION 37



$V = \frac{33}{6} \times 21.3 \times 2.5 \times .15 = 81 in^3$

STA 92: $V = \frac{70}{8} \times 21.4 \times 2.5 \times .12 = 54 in^3$

STA 92: $V = \frac{64}{8} \times 18.1 \times 2.5 \times .10 = 36 in^3$

STA 172: $V = \frac{55}{8} \times 15.3 \times 2.5 \times .09 = 24 in^3$

STA 253: $V = \frac{48}{8} \times 12.5 \times 2.5 \times .075 = 14 in^3$

STA 333: $V = \frac{40}{8} \times 9.8 \times 2.5 \times .063 = 8 in^3$

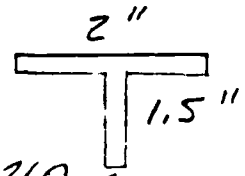
TIP: $V = \frac{48}{8} \times 9.3 \times .063 \times 2.5 = 8 in^3$

$\Sigma V = 225 in^3$ $WT = .101 \times 225 = 23 LB$

TORQUE BOX

RIBS (CONT)

CAPS



ROOT $V = 2 \times 93 \times 3.5 \times .4 = 260 in^3$

STA 27: $V = 2 \times 70 \times 3.5 \times .150 = 74 in^3$

STA 92: $V = 2 \times 64 \times 3.5 \times .125 = 56 in^3$

STA 172: $V = 2 \times 55 \times 3.5 \times .100 = 39 in^3$

STA 253: $V = 2 \times 48 \times 3.5 \times .10 = 34 in^3$

STA 333: $V = 2 \times 40 \times 3.5 \times .10 = 28 in^3$

TIP: $V = 2 \times 49 \times 3.5 \times .10 = 34 in^3$

$\Sigma V = 559 in^3$

$WT = 559 \times .101 = 56$ LB.

FORMER-RIBS

ROOT TO 27

WEB: $V = 40 \times 20.8 \times .04 = 33 in^3$

WEB STIFFENERS: $V = \frac{40}{8} \times 20.8 \times 2.0 \times .05 = 10 in^3$

CAPS $V = 40 \times 2 \times 3.0 \times .05 = 12 in^3$

$55 in^3$

STA 27-92

WEB: $V = 67 \times 19.3 \times .04 = 52 in^3$

WEB STIFF $V = \frac{67}{8} \times 19.3 \times 2.0 \times .05 = 16 in^3$

CAPS: $V = 67 \times 2 \times 3.0 \times .05 = 20 in^3$

$88 in^3$

Torque Box

Formers

STA 92-172

WEB $V = 60 \times 17.3 \times .04 =$ 42 in^3

(2) WEB STIFF $V = 17.3 \times \frac{60}{8} \times 2.0 \times .05 =$ 13 in^3

CAPS $V = 2 \times 60 \times 3.0 \times .05 =$ 18 in^3

73 in^3
X2
146

STA 172-253

WEB $V = 52 \times 13.9 \times .04 =$ 29 in^3

WEB STIFF $V = \frac{52}{8} \times 13.9 \times 2.0 \times .05 =$ 9 in^3

CAPS $V = 2 \times 52 \times 3.0 \times .05 =$ 16 in^3

54 in^3
X2
108

STA 253 TO 297

WEB $V = 44 \times 11.2 \times .04 =$ 20 in^3

WEB STIFF. $V = \frac{44}{8} \times 11.2 \times 3.0 \times .05 =$ 6 in^3

CAPS $V = 2 \times 44 \times 3.0 \times .05 =$ 13 in^3

39 in^3
X2
78

$$\Sigma V = 55 + 83 + 146 + 108 + 78 = 475$$

$$Wt = .101 \times 475 = \underline{48 \text{ LB}}$$

VENTRAL FIN

TRAILING EDGE

COVER STRINGERS – OUTB'D & INB'D (.7C-AFT)	29
COVER SKIN – OUTBOARD	108
COVER STRINGERS OUTBOARD	55
COVER SKIN – INBOARD	83
COVER STRINGERS – INBOARD	37
REAR SPAR/TRAILING EDGE	73
RIBS	63
FORMERS	41
ATTACH, SPLICES, JOINTS	60
OUTB'D AND INB'D SKIN (.7C-AFT)	84
	633 LB

COVER WEIGHT = 29+108+55+83+84+37

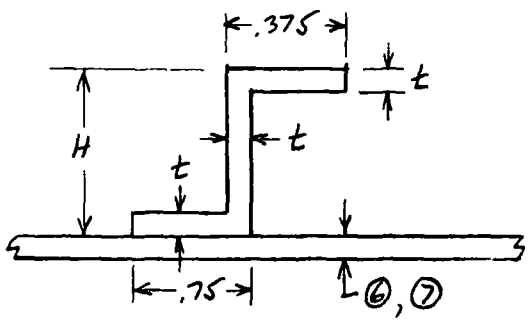
= 396 LB

VENTRAL FIN

TRAILING EDGE

INBOARD STRINGERS, R.S. TO .7C
6 IN. SPACING. MAT'L. 7075-T73

SWEPT STA.	t	H	NO. PER BOOSTER	UNIT AREA
56	.10	2.0	16	.293
80	.10	1.85	14	.278
103	.10	1.75	14	.268
172	.09	1.45	12	.216
226	.08	1.2	12	.173
264	.07	1.0	10	.139
356	.045	.55	8	.071
370.5	.04	.5		.062



$16(80-56)/3\,[.293 + .278 + \sqrt{.293(.278)}\,]\,.101 = 11.1$
$14(103-80)/3\,[.278 + .268 + \sqrt{.278(.268)}\,]\,.101 = 8.9$
$14(172-103)/3\,[.268 + .216 + \sqrt{.268(.216)}\,]\,.101 = 23.6$
$12(226-172)/3\,[.216 + .173 + \sqrt{.216(.173)}\,]\,.101 = 12.7$
$12(264-226)/3\,[.173 + .139 + \sqrt{.173(.139)}\,]\,.101 = 7.2$
$10(356-264)/3\,[.139 + .071 + \sqrt{.139(.071)}\,]\,.101 = 9.6$
$8(370.5-356)/3\,[.071 + .062 + \sqrt{.071(.062)}\,]\,.101 = 0.8$

TOTAL WEIGHT = 73.9 LB., $W_{VERT\ FIN}$ = 37 LB

OUTB'D. SKIN, R.S. TO .7C (CONT'D.)

$2(103-49.5)/6\,[.12(44)+.12(40.5)+(.12+.12)(44+40.5)].101 = 54.8$
$2(226-103)/6\,[.12(40.5)+.10(32)+(.12+.10)(40.5+32)].101 = 99.4$
$2(370.5-226)/6\,[.10(32)+.05(23)+(.10+.05)(32+23)]\,101 = 61.3$

TOTAL WEIGHT = 215.5 LB. $WT_{/FIN}$ = 108 LB

INBOARD SKIN, R.S. TO .7C (2 PER BOOSTER)

SWEPT STA.	⑦	C (IN.)
56	.10	44
103	.10	40.5
370.5	.04	23

MAT'L. 7075-T73

$2(103-56)/6\,[.10(44)+.10(40.5)+(.10+.10)(44+40.5)].101 = 40.1$
$2(370.5-103)/6\,[.10(40.5)+.04(23)+(.10+.04)(40.5+23)].101 = 124.8$

TOTAL WEIGHT = 164.9 LB., $WT_{/FIN}$ = 82 LB

OUTB'D. AND INB'D. SKIN, .7C TO T.E.S. (2 EA. PER BOOSTER)

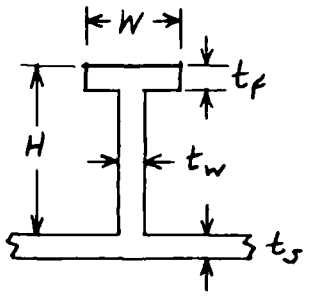
SWEPT STA.	⑤	C (IN.)
79	.05	38.5
226	.05/.04	30
385	.04	20.5

MAT'L, 7075-T73

$4(226-79)/6\,[.05(38.5)+.05(30)+(.05+.05)(38.5+30)].101 = 101.7$
$4(385-226)/6\,[.04(30)+.04(20.5)+(.04+.04)(30+20.5)].101 = 64.9$

TOTAL WEIGHT = 166.6 LB., $WT_{/FIN}$ = 83.3 LB

OUTBOARD INTEGRAL STRINGERS, F.S. TO R.S.
4 IN. SPACING. MAT'L. 7075-T73



OUTB'D. AND INB'D. STRINGERS, .7C TO T.E.S.
8 IN. SPACING. MAT'L. 7075-T73

SWEPT STA.	t_N	H	NO. PER BOOSTER	UNIT AREA
79	.08	2.0	16	.237
103	.08	1.9	16	.229
189	.06	1.5	12	.150
226	.05	1.3	12	.116
325	.05	.8	8	.091
385	.05	.5		.076

$16(103-79)/3\left[.237+.229+\sqrt{.237(.229)}\right].101 = 9.0$
$16(189-103)/3\left[.229+.150+\sqrt{.229(.150)}\right].101 = 26.1$
$12(226-189)/3\left[.150+.116+\sqrt{.150(.116)}\right].101 = 5.9$
$12(325-226)/3\left[.116+.091+\sqrt{.116(.091)}\right].101 = 12.4$
$8(385-325)/3\left[.091+.076+\sqrt{.091(.076)}\right].101 = 4.0$

TOTAL WEIGHT = 57.4 LB., $WT/_{FIN}$ = 28.7 LB

OUTBOARD STRINGERS, R.S. TO .7C
6 IN. SPACING. MAT'L. 7075-T73

SWEPT STA.	t	H	NO. PER BOOSTER	UNIT AREA
49.5	.15	2.0	16	.424
80	.15	1.85	14	.401
103	.15	1.75	14	.386
172	.135	1.45	12	.311
226	.12	1.20	12	.250
264	.10	1.0	10	.193
356	.055	.55	8	.086
370.5	.05	.5		.076

$16(80-49.5)/3\left[.424+.401+\sqrt{.424(.401)}\right].101 = 20.3$
$14(103-80)/3\left[.401+.386+\sqrt{.401(.386)}\right].101 = 12.8$
$14(172-103)/3\left[.386+.311+\sqrt{.386(.311)}\right].101 = 33.9$
$12(226-172)/3\left[.311+.250+\sqrt{.311(.250)}\right].101 = 18.3$
$12(264-226)/3\left[.250+.193+\sqrt{.250(.193)}\right].101 = 10.2$
$10(356-264)/3\left[.193+.086+\sqrt{.193(.086)}\right].101 = 12.6$
$8(370.5-356)/3\left[.086+.076+\sqrt{.086(.076)}\right].101 = 0.9$

TOTAL WEIGHT = 109.0 LB, $WT/_{FIN}$ = 54.5 LB

TRAILING EDGE

RIBS

CAPS & WEB STIFFENERS

ROOT: $V = 2 \times 95 \times 3.5 \times .12 + \frac{95}{8} \times 15.8 \times 2.5 \times .12 = 136$

STA 92: $V = 2 \times 79 \times 3.5 \times .08 + \frac{79}{8} \times 13.6 \times 2.5 \times .08 = 91$

STA 172: $V = 2 \times 69 \times 3.5 \times .063 + \frac{69}{8} \times 11.0 \times 2.5 \times .063 = 46$

STA 253: $V = 2 \times 59 \times 3.5 \times .05 + \frac{59}{8} \times 8.4 \times 2.5 \times .05 = 28$

STA 333: $V = 2 \times 49 \times 3.5 \times .05 + \frac{49}{8} \times 5.8 \times 2.5 \times .05 = 22$

TIP: $V = 2 \times 52 \times 3.5 \times .05 + \frac{52}{8} \times 4.8 \times 2.5 \times .05 = 19$

$\Sigma V = 322 \text{ in}^3$, $W_T = .101 \times 322 = 33 \text{ LB}$

FORMER-RIBS

ROOT TO STA 92

WEB: $40 \times 14.7 \times .04 =$ 24 in^3

WEB STIFFENERS, $\frac{40}{8} \times 14.7 \times .05 \times 2.0 =$ 7

CAPS: $2 \times 40 \times 3.5 \times .05 =$ 14

45 in^3

STA 92 TO STA 172

WEB: $72 \times 12.3 \times .04 =$ 35

WEB STIFF: $\frac{72}{8} \times 2.0 \times 12.3 \times .05 =$ 11

CAPS: $72 \times 2 \times 3.5 \times .05 =$ 25

71 in^3

$\times 2$

142 in^3

VENTRAL FIN
TRAILING EDGE

RIB WEBS, R.S. TO T.E.S. (2 EA. PER BOOSTER) MAIN

SWEPT STA.	(III)	WIDTH	AVG. DEPTH (IN.) MAT'L. 7075-T73
ROOT	.10	95	15.8
92	.06	79	13.6
172	.053	69	11.0
253	.047	59	8.4
333	.04	49	5.8
TIP	.04	52	4.8

2(.10) 95 (15.8 .101 = 30.3
2(.06) 79 (13.6 .101 = 13.0
2(.053) 69 (11.0 .101 = 8.1
2(.047) 59 8.4) .101 = 4.7
2(.04) 49 5.8 .101 = 2.3
2(.04) 52 (4.8 .101 = 2.0

TOTAL WEIGHT = 60.4 LB. , WT/FIN = 30.2 LB

RIB WT = 30 + 32 = 62 LB

TRAILING EDGE

FORMER RIBS (CONT)

STA 172 TO 253

WEB: $64 \times .04 \times 9.7 =$ 25

WEB STIFF: $\frac{64}{8} \times .05 \times 2.0 \times 9.7 =$ 8

CAPS: $2 \times 64 \times 5.5 \times .05 =$ 22

55 in^3

$\times 2$

110 in^3

STA 253 TO 333

WEB. $54 \times 7.1 \times .04 =$ 15

WEB STIFF $\frac{54}{8} \times 7.1 \times .05 \times 2.0 =$ 5

CAPS: $2 \times 54 \times .05 \times 3.5 =$ 19

39 in^3

$\times 2$

78 in^3

STA 333 TO TIP

WEB: $45 \times 5.3 \times .04 =$ 10

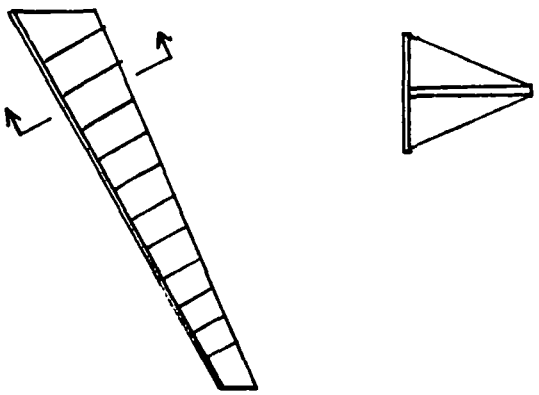
WEB STIFF $\frac{45}{8} \times 5.3 \times .05 \times 2.0 =$ 3

CAPS $2 \times 45 \times .05 \times 3.5 =$ 16

29 in^3

$\Sigma V = 404\ in^3$, $WT = .101 \times 404 =$ 41 LB

TRAILING EDGE MEMBER



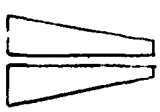
CHORDWISE WEB

$$\text{AREA} = \frac{21.5+13}{2} \times 300 + 21.5 \times 10 \times \frac{1}{2} + 6 \times 13 \times \frac{1}{2} = 5321 \text{ in}^2$$

$$t = .08$$

$$V = .08 \times 5321 = 425 \text{ in}^3$$

WEB GUSSETS



$$V_{AVG} = 17.0 \times 4 \times .08 \times 2 = 10.9$$

$$\Sigma V = \frac{300}{14} \times 10.9 = 214 \text{ in}^3$$

CAP

$$V = 310 \times .08 \times \frac{5+1.5}{2} = 81 \text{ in}^3$$

$$\Sigma V = 425 + 214 + 81 = 720$$

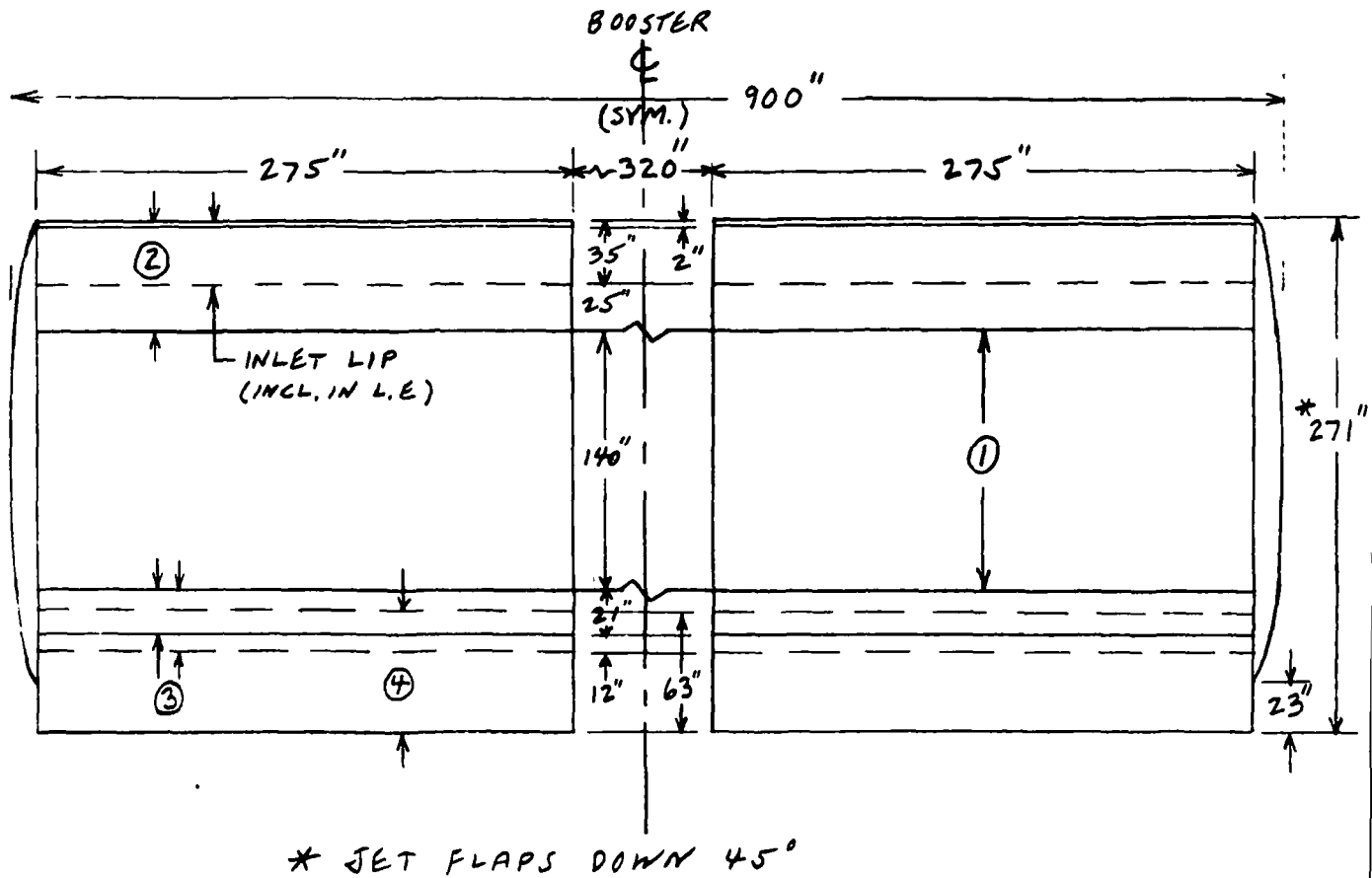
$$W_T = .101 \times 720 = \underline{\underline{73 \text{ LB}}}$$

		WEIGHT (LB) PER BOOSTER
CANARD		[7,780]
TORQUE BOX	(3,944)	
COVERING (UPPER)	701	
SKIN	332	
STRINGERS	322	
SPLICES, ATTACHMENTS (JSF)	47	
FORWARD SPAR	716	
SHEAR WEB	117	
WEB STIFFENERS	253	
CAPS	298	
SPLICES, ATTACHMENTS (JSF)	48	
AFT SPAR	609	
SHEAR WEB	113	
WEB STIFFENERS	215	
CAPS	235	
SPLICES ATTACHMENTS (JSF)	46	
RIBS (12)	1,067	
SHEAR WEB	581	
WEB STIFFENERS (INTEGRAL)	338	
CAPS (INTEGRAL)	67	
FILLETS, BOSSES, ATTACHMENTS	81	
REMOVABLE PANELS (LOWER) (10)	568	
STRUCTURE	278	
MECHANISM	290	
TIPS	211	
BODY ATTACHMENT	72	
UPPER SKIN	5	
FORWARD SPAR CAPS	43	
AFT SPAR CAPS	24	

LEADING EDGE	(1,850)
FORWARD EDGE (HOT)	423
COVER	274
BEAMS	56
INSULATION	8
SEAL	30
SPLICES, ATTACHMENTS	55
COVERS	357
SKIN	195
STRINGERS	87
STIFFENERS	11
SPLICES, ATTACHMENTS	64
SPAR	168
WEB	39
STIFFENERS	10
CAPS	89
SPLICES, ATTACHMENTS	30
RIBS	130
FORMERS	107
INLET LIP (MOVABLE)*	665
FORWARD EDGE (HOT)	254
COVERS	136
SPARS	125
RIBS	71
RAMPS (ENGINE AIR DUCTS)	25
SPLICES, ATTACHMENTS	54
TRAILING EDGE	(380)
COVERS	165
SKIN	95
STRINGERS	19
SPLICES, ATTACHMENTS	51
RIBS	154
FORMERS	61

	WEIGHT (LB) PER BOOSTER
JET FLAPS (STRUCT) - 10	(1,149)
COVERS	647
SKIN	224
CORRUGATION	299
SPLICES, ATTACHMENTS	124
SPAR	(135)
WEB	55
CAPS	54
SPLICES, ATTACHMENTS	26
TRAILING EDGE MEMBER	24
RIBS	287
FLAP INTERCONNECTION (FLEX. SKIN)	56
JET FLAP SUPPORTS	(457)
HINGE FITTINGS	170
CONTROL FITTING	287

DETAILED WEIGHT SUBSTANTIATION (CANARD GROUP)



* JET FLAPS DOWN 45°

2. TAIL GROUP	VERTICAL	HORIZ
BASIC STRUCTURE	( )	(6174)
① TORQUE BOX		3944
CARRY THROUGH		
② LEADING EDGE		1850
③ TRAILING EDGE		310
SECONDARY STRUCTURE		
CONTROL SURFACES	SURFACE	SUPT/MECH
RUDDERS		
④ JET FLAPS	1149	457

DETAILED WEIGHT SUBSTANTIATION (CANARD GROUP)

INTRODUCTION

THE CANARD GROUP DETAILED WEIGHT SUBSTANTIATION PRESENTS WEIGHTS OF THE VARIOUS CANARD STRUCTURAL ELEMENTS AS DETERMINED ON THE BASIS OF STRESS ANALYSIS. IN A FEW CASES, NAMELY ENGINE ACCESS DOOR PANEL MECHANISM, TIPS, AND SPLICES AND ATTACHMENTS (JSF), WEIGHTS ARE BASED ON THE WEIGHT ENGINEER'S JUDGEMENT.

THE FOLLOWING DATA IS INCLUDED HEREIN:

DETAILED WEIGHT STATEMENT
CANARD SKETCH WITH GROUP WEIGHT STATEMENT
STRUCTURAL DESCRIPTION
DETAILED WEIGHT SUBSTANTIATION
FIGURE OF SPAR MATERIAL REQUIREMENTS
COMPARITIVE TAIL UNIT WEIGHTS
LIMIT LOAD CONDITIONS OF BENDING MOMENT, SHEAR AND TORSION
TPS DATA SHEET
CANARD STRUCTURE ASSEMBLY DWG. 899A2010639

DETAILED WEIGHT SUBSTANTIATION (CANARD GROUP)

STRUCTURAL DESCRIPTION

THE CANARD CONSISTS OF A FIXED SURFACE CANTILEVERED FROM EACH OF THE L.H. AND R.H. SIDES OF THE BOOSTER FOREBODY. THE BODY CARRY-THRU STRUCTURE IS CONSIDERED AND DISCUSSED IN THE BODY.

EACH FIXED SURFACE CONSISTS OF A Π-SHAPED TORQUE BOX COMPRISED OF FRONT AND REAR SPARS CONNECTED WITH AN UPPER COVER. 10 ENGINE ACCESS PANELS ARE INSTALLED ACROSS THE LOWER OPENING OF THE TORQUE BOX.

ALSO INCLUDED ARE UPPER AND LOWER FIXED LEADING EDGES, WITH AN INLET LIP HINGED FROM THE LOWER PORTION TO PERMIT CLOSING OF THE L.E. DURING ASCENT AND DESCENT, AND OPENING OF THE L.E DURING ATMOSPHERIC CRUISE TO PROVIDE AIR FOR THE 10 JET ENGINES BURIED WITHIN THE CANARD.

ALSO, UPPER AND LOWER FIXED TRAILING EDGES, WITH 10 INTERCONNECTED JET FLAPS HINGED FROM THE LOWER PORTION TO PROVIDE AERODYNAMIC CONTROL IN CONJUNCTION WITH THE JET ENGINE EXHAUST DIRECTED OVER THE TOP SURFACE OF THE FLAPS.

THE OUTBOARD ENDS OF THE CANARD ARE FINISHED OFF WITH TIP FAIRINGS.

A BRIEF SUMMARY OF TYPE OF CONSTRUCTION AND MATERIAL FOLLOWS.

SECTION	CONSTRUCTION	MATERIAL
TORQUE BOX	UPPER COVER OF SHEET WITH ATTACHED STRINGERS (5 I's PLUS 12 L's); F.S. AND R.S. OF SHEET WEB, L STIFFENERS, ⊥ ENGINE CUTOUT FLANGES, I UPPER CHORDS AND ⊥ LOWER CHORDS; 12 RIBS MACHINED FROM 2.5 IN. PLATE; BODY ATTACHMENT:	7075-T73 (EXCEPT AS NOTED)

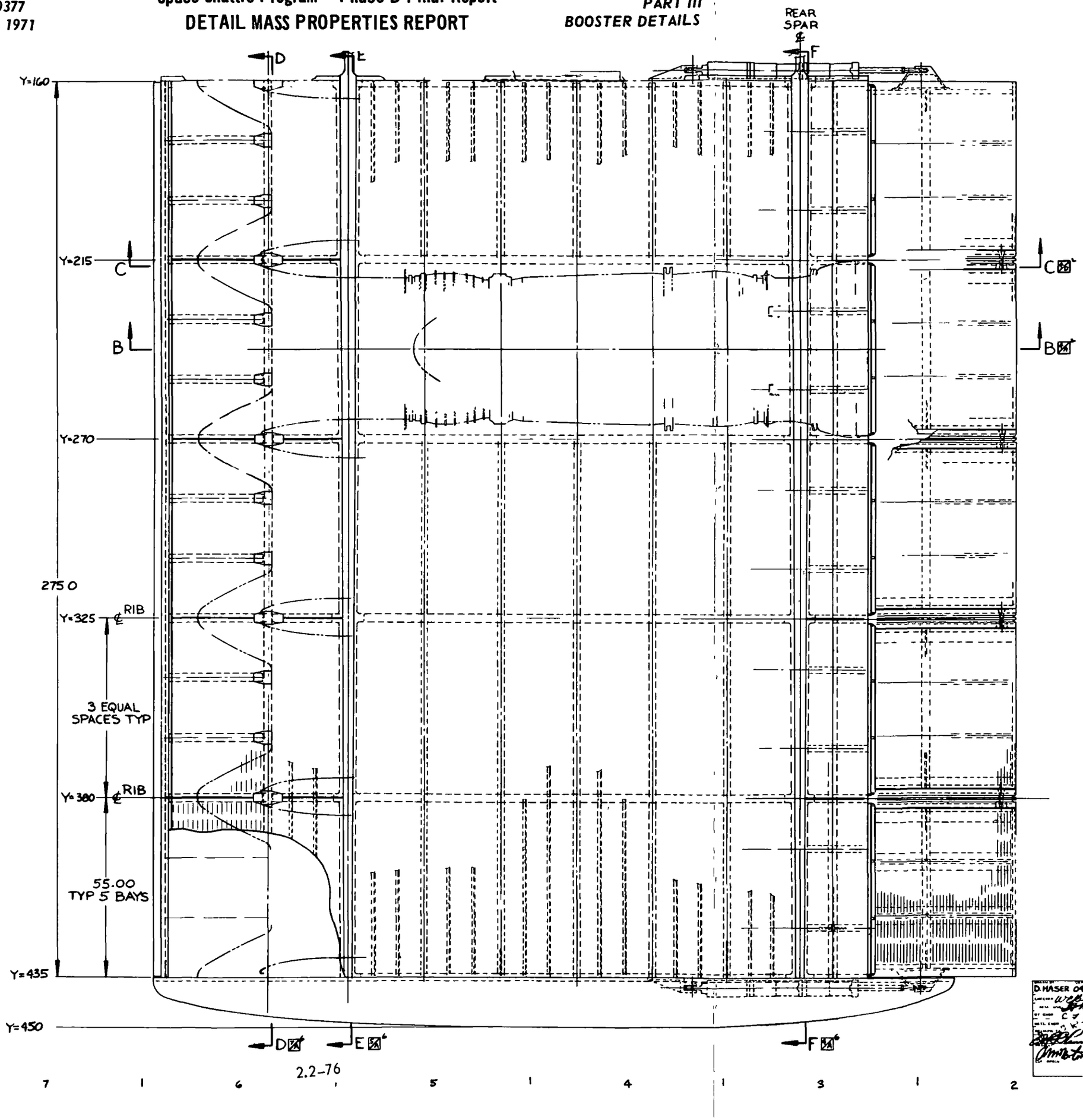
SECTION	CONSTRUCTION	MATERIAL
TORQUE BOX (CONT'D)	UPPER COVER SHEAR STRAP, 8-1 IN. DIA. STEEL BOLTS AT UP. + LOW. F.S. CHORDS, 8-7/8 IN. DIA. STEEL BOLTS AT UP. + LOW. R.S. CHORDS; TIPS OF COVER SHEET AND FORMED RIBS; OPEN FRAMEWORK ENG. ACCESS PANELS (10) WITH TORQUE TUBE/PUSH ROD SYSTEM, 10 LATCH PINS PER PANEL.	STEEL SOME STEEL AND PHOSPHOR BRONZE
LEADING EDGE	HOT FORWARD EDGE OF DOUBLE SHEET COVER AND BUILT-UP BEAM; AFT INTERNAL INSULATION; EXTERNAL METAL BRUSH SEAL (CONTACTS INLET LIP IN CLOSED POSITION).	HASTELLOY X
	MAIN STRUCTURE OF SKIN AND ATTACHED STRINGERS, BUILT-UP BEAM, MACHINED RIBS AND FORMERS, CORRUGATION (FWD. OF ENG. AIR DUCT),	7075-T73 (EXCEPT AS NOTED) TITANIUM
	INLET LIP HOT FORWARD EDGE OF DOUBLE SHEET COVER AND BUILT-UP BEAM; AFT INTERNAL INSULATION.	HASTELLOY X
	INLET LIP MAIN STRUCTURE OF BUILT-UP SPARS, LOWER REAR SKIN AND ATTACHED STRINGERS;	7075-T73
	UPPER AND LOWER FRONT SKIN AND CORRUGATION, MACHINED MAIN RIBS AND FORMED INTERMED. RIBS, ENG. AIR DUCT RAMPS.	TITANIUM

SECTION	CONSTRUCTION	MATERIAL
TRAILING EDGE	FRONT UPPER SKIN AND MACHINED RIBS AND FORMERS;	7075-T73
	REAR UPPER SKIN AND ATTACHED STRINGERS AND MACHINED RIBS AND FORMERS, LOWER SKIN, MACHINED RIBS AND BENT-UP FORMERS.	TITANIUM
JET FLAPS	SKIN AND CORRUGATION COVERING, BUILT-UP SPAR, T.E. MEMBER, MACHINED DRIVE RIB, BUILT-UP HINGE RIBS, BENT-UP INTERMED. RIBS, FLEXIBLE INTERCONNECTING SKINS, HINGE AND CONTROL FITTINGS, DRIVE PIN INTERCONNECTING FITTINGS.	L605

DETAILED WEIGHT SUBSTANTIATION
(CANARD GROUP)

	WEIGHT (LB.)	PLAN AREA (SQ. FT.)	UNIT WEIGHT (LB./SQ. FT.)
EXPOSED CANARD – SHUTTLE BOOSTER			
TORQUE BOX (INCL. ENG. PANELS)	3944	535	7.37
LEADING EDGE (INCL. INLET LIP)	1850	230	8.04
INLET LIP	665	134	4.96
TRAILING EDGE	380	126	3.02
JET FLAPS	1606	241	6.66
ENGINE ACCESS PANELS	568	535	1.06
OVERALL	7780	1087	7.16
EXPOSED ALL-MOVABLE CANARD – XB-70A			
TORQUE BOX	1919	124.5	15.41
LEADING EDGE	245	48.0	5.10
TRAILING EDGE	0	–	–
FLAPS	584	92.8	6.29
AERODYNAMIC SEALS	84	–	–
PAINT	29	172.5	0.17
OVERALL	2861	265.3	10.78
EXPOSED ALL-MOVABLE HORIZONTAL TAIL – X-15A-2			
TORQUE BOX	360	43.5	8.28
LEADING EDGE	71	4.8	14.79
TRAILING EDGE	7	–	–
OVERALL	438	48.3	9.07
HORIZONTAL TAIL – B-52G			
TORQUE BOX LEADING EDGE TRAILING EDGE	3728	821	4.54
ELEVATORS	502	79	6.35
OVERALL	4230	900	4.70

	WEIGHT (LB.)	PLAN AREA SQ.FT.	UNIT WEIGHT LB./SQ.FT.
EXPOSED HORIZONTAL TAIL - C-133B			
TORQUE BOX	1878		
LEADING EDGE	326		
TRAILING EDGE	0		
ELEVATORS	1517		
FAIRING	86		
OVERALL	3807	800.7	4.75
EXPOSED HORIZONTAL TAIL - C-135A			
TORQUE BOX	1442	270	5.34
LEADING EDGE	156	38.5	4.05
TRAILING EDGE	121	—	—
ELEVATORS	1009	125	8.07
AERODYNAMIC SEALS	32	—	—
OVERALL	2760	433.5	6.37



UPPER SURFACE
(TPS REMOVED)

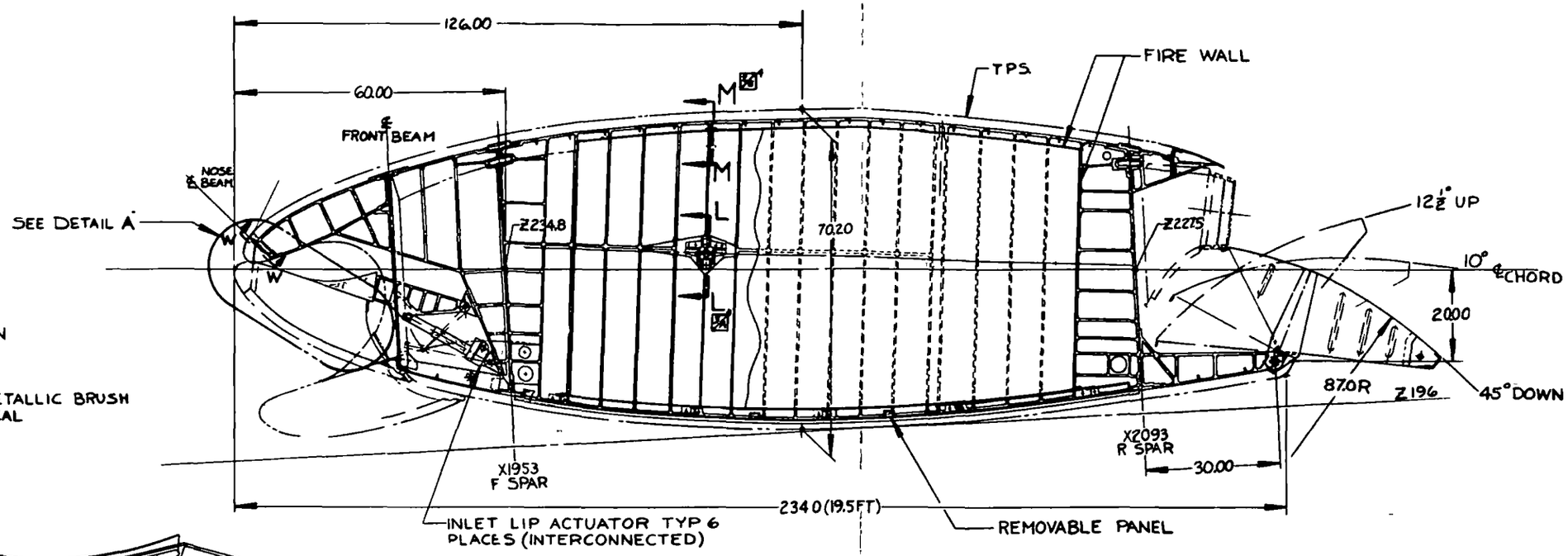
D.HASER 0435 6-9-71

MARTIN MARIETTA CORPORATION

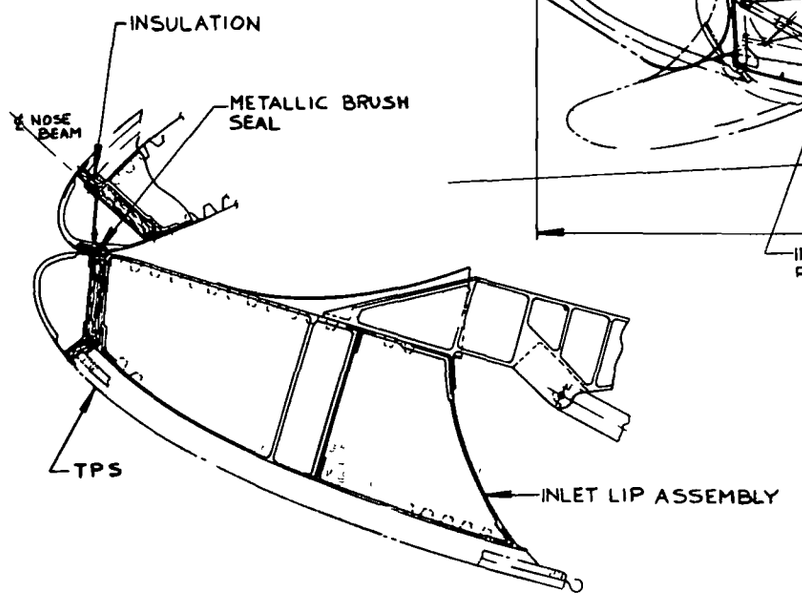
CANARD STRUCTURE ASSEMBLY CONFIGURATION 20B

SIZE E | CODE IDENT NO. 04236 | 899A2010639

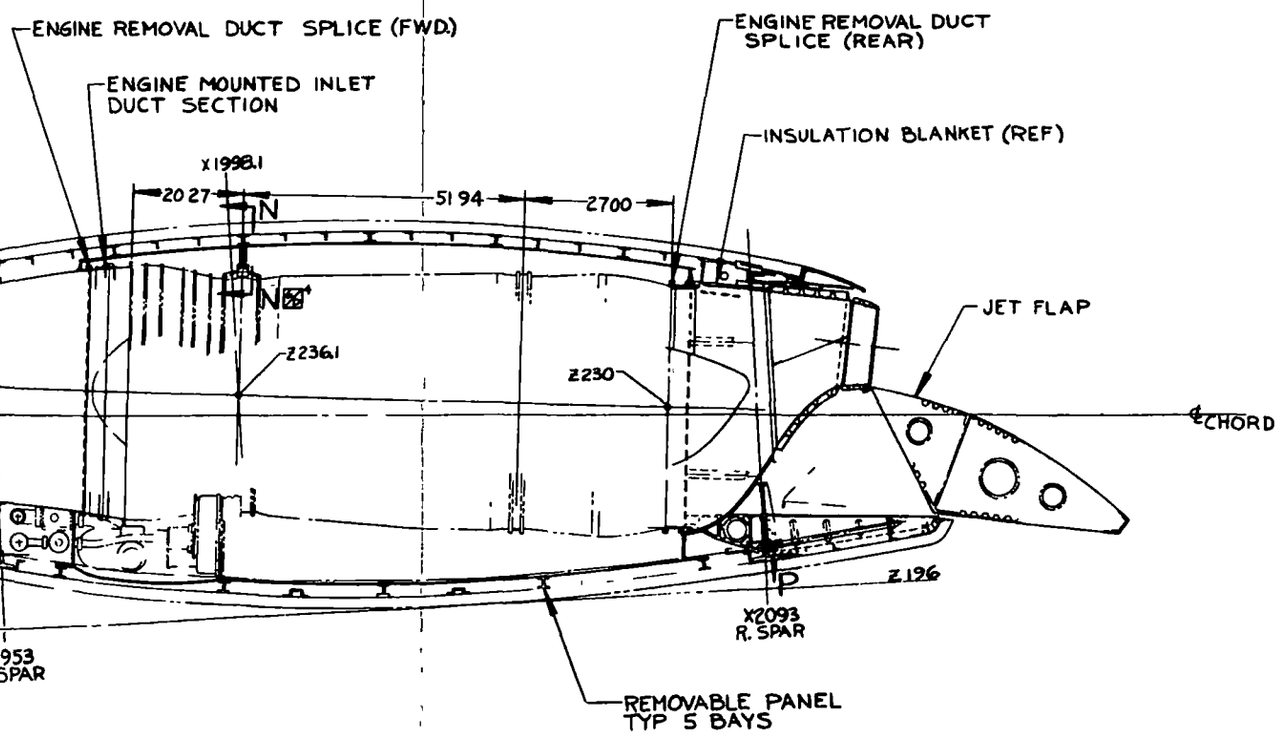
SCALE 1/10 | SHEET 1 OF 6



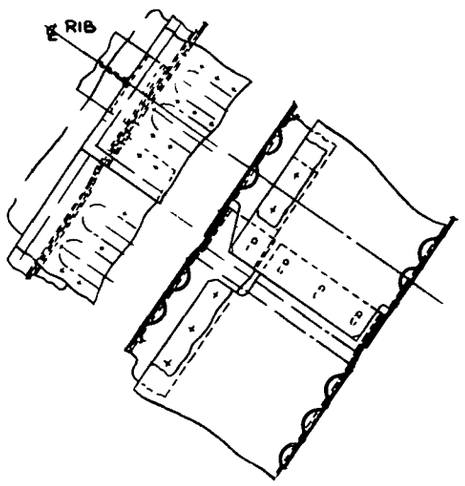
SECTION C-C



DETAIL A
(¼ SCALE)



SECTION B-B



VIEW W-W
(½ SCALE)

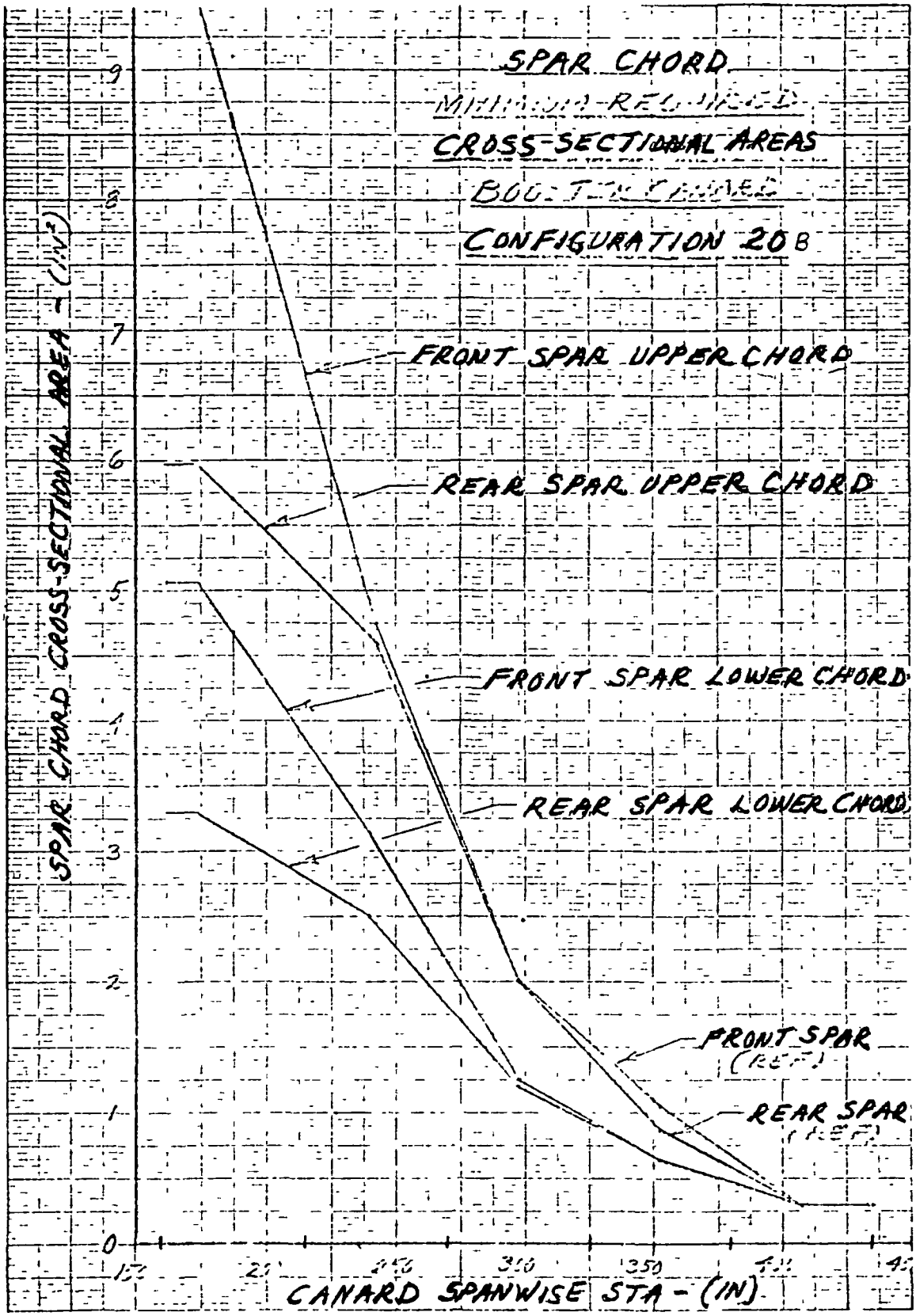
D.NASER ORIG 6-11-71

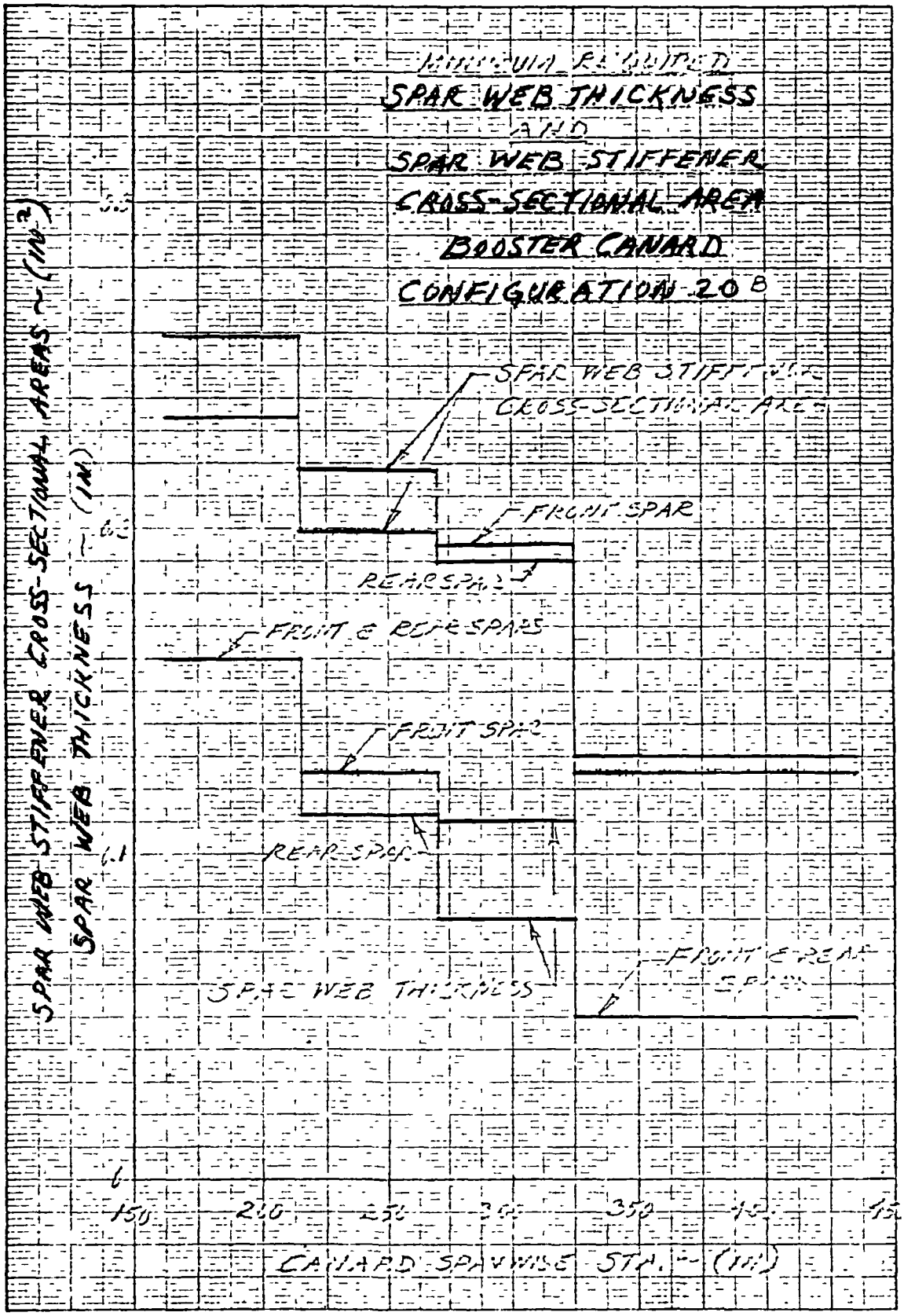
MARTIN MARIETTA CORPORATION

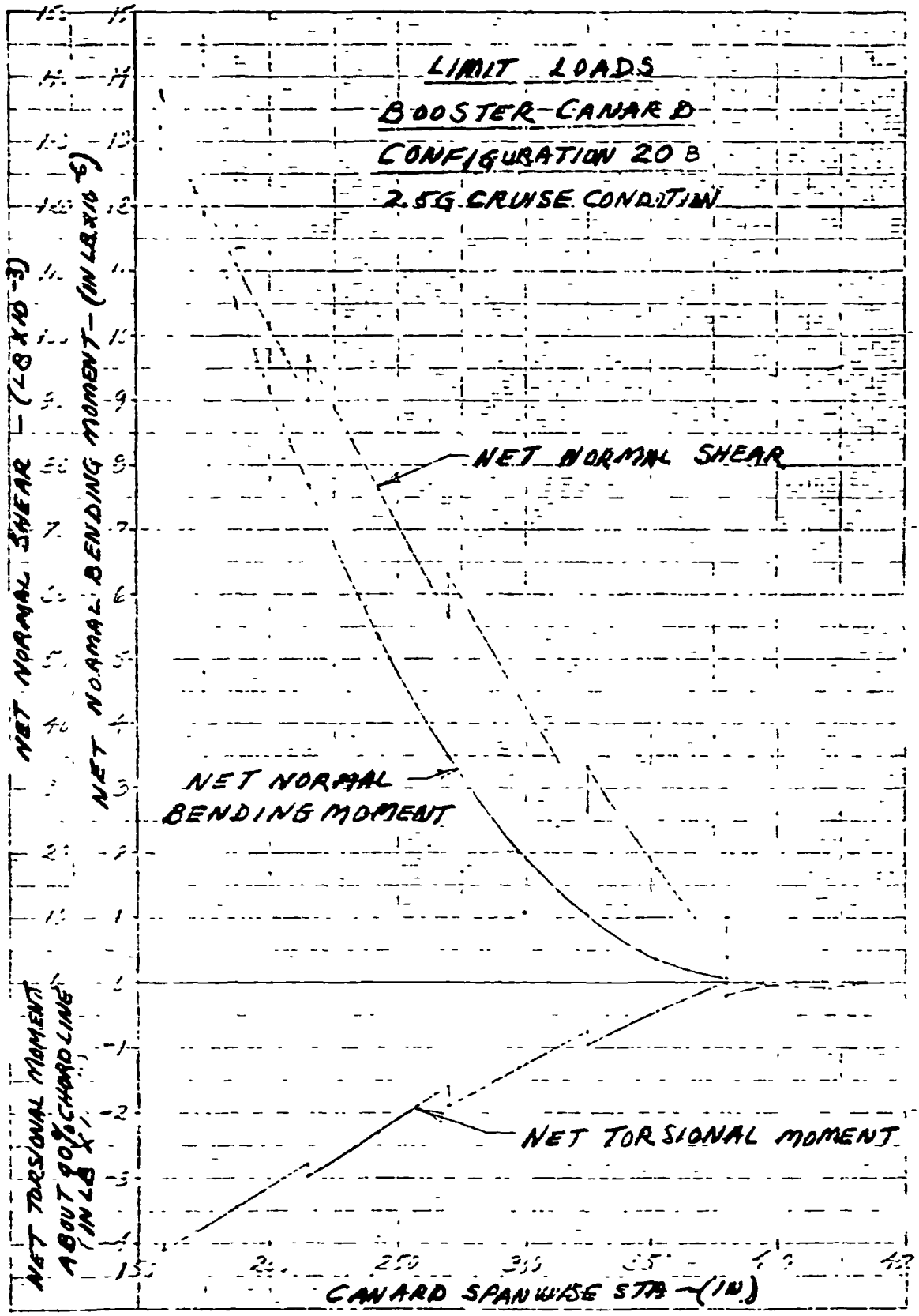
CANARD STRUCTURE ASSEMBLY
CONFIGURATION 20B

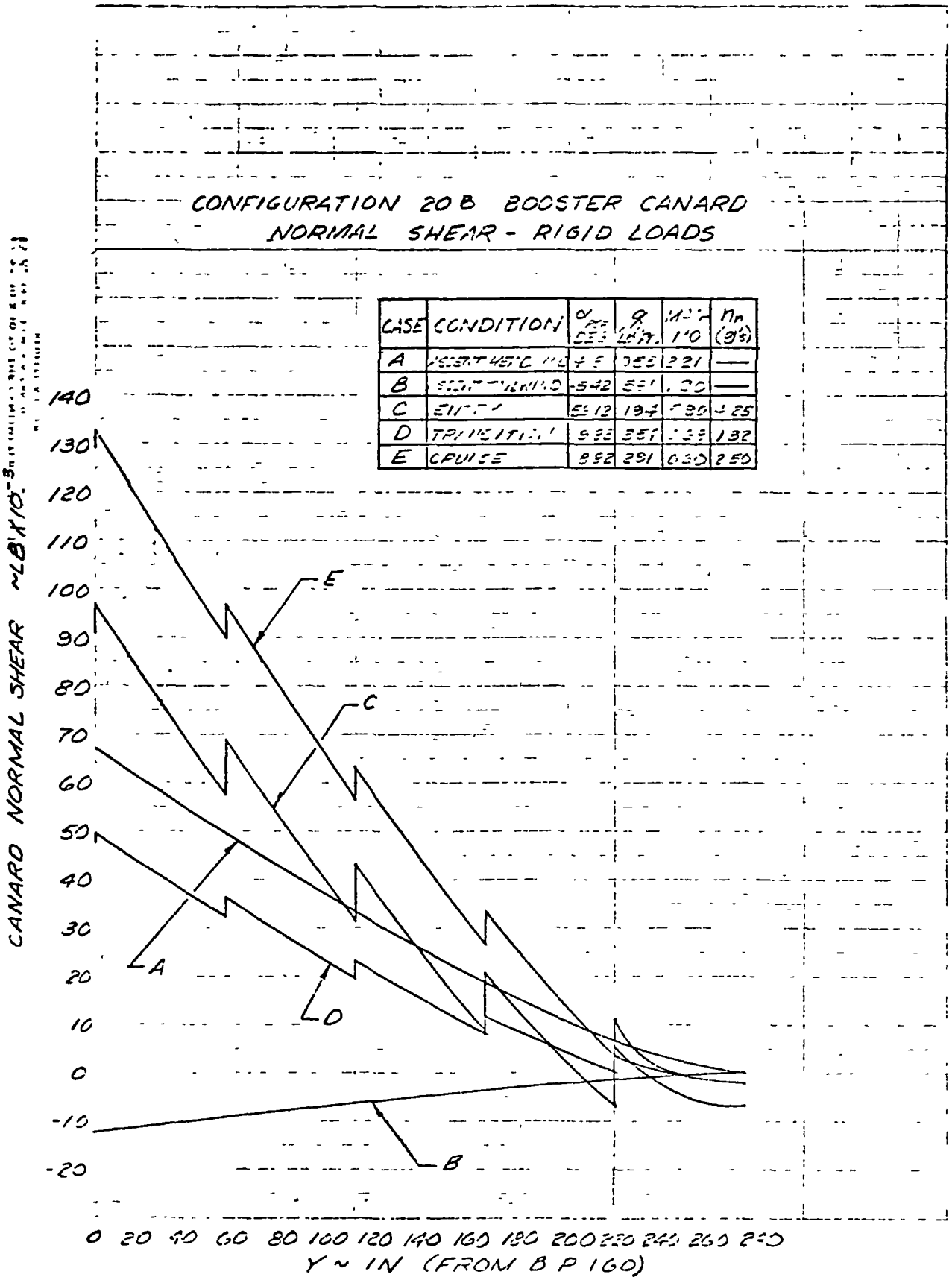
E 04236 899A2010639

UNLESS OTHERWISE NOTED

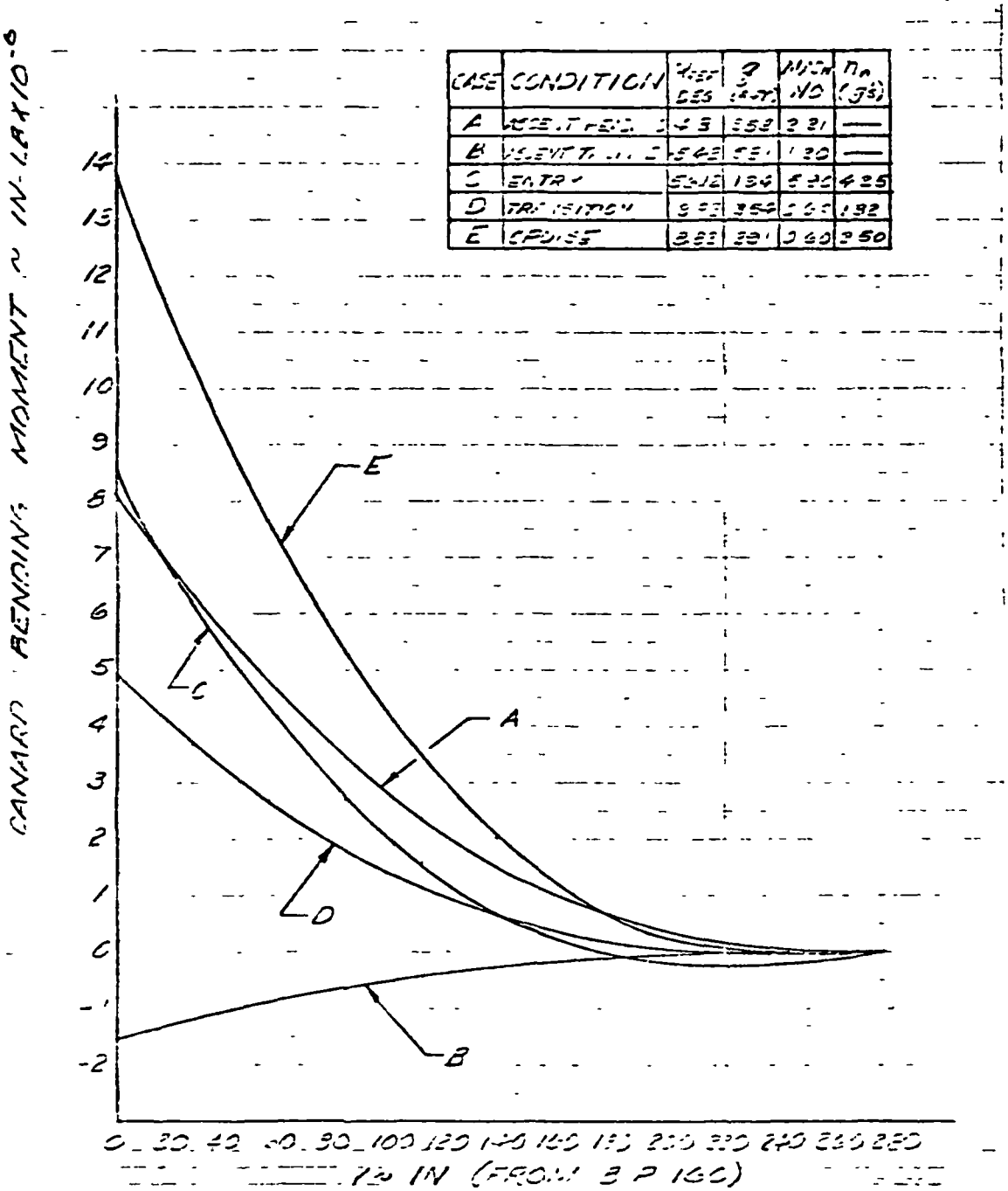

SPAR CHORD
CROSS-SECTIONAL AREAS
CONFIGURATION 20B
FRONT SPAR UPPER CHORD
REAR SPAR UPPER CHORD
FRONT SPAR LOWER CHORD
REAR SPAR LOWER CHORD
FRONT SPAR
REAR SPAR
SPAR CHORD CROSS-SECTIONAL AREA - (IN²)
CANARD SPANWISE STA - (IN)
0
1
2
3
4
5
6
7
8
9
310
350


MINIMUM REQUIRED
SPAR WEB THICKNESS
AND
SPAR WEB STIFFENER
CROSS-SECTIONAL AREA
BOOSTER CANARD
CONFIGURATION 20B
SPAR WEB STIFFENER CROSS-SECTIONAL AREAS ~ (IN²)
SPAR WEB THICKNESS (IN)
SPAR WEB STIFFENER CROSS-SECTIONAL AREA
FRONT SPAR
REAR SPAR
FRONT & REAR SPARS
FRONT SPAR
REAR SPAR
SPAR WEB THICKNESS
FRONT & REAR SPARS
CANARD SPANWISE STA. (IN)


LIMIT LOADS
BOOSTER CANARD
CONFIGURATION 20 B
2.5G CRUISE CONDITION
NET NORMAL SHEAR
NET NORMAL BENDING MOMENT
NET TORSIONAL MOMENT
NET NORMAL SHEAR (LB X10⁻³)
NET NORMAL BENDING MOMENT (IN-LB X10⁻⁶)
NET TORSIONAL MOMENT ABOUT 50% CHORDLINE (IN-LB X10⁻⁶)
CANARD SPANWISE STA (IN.)

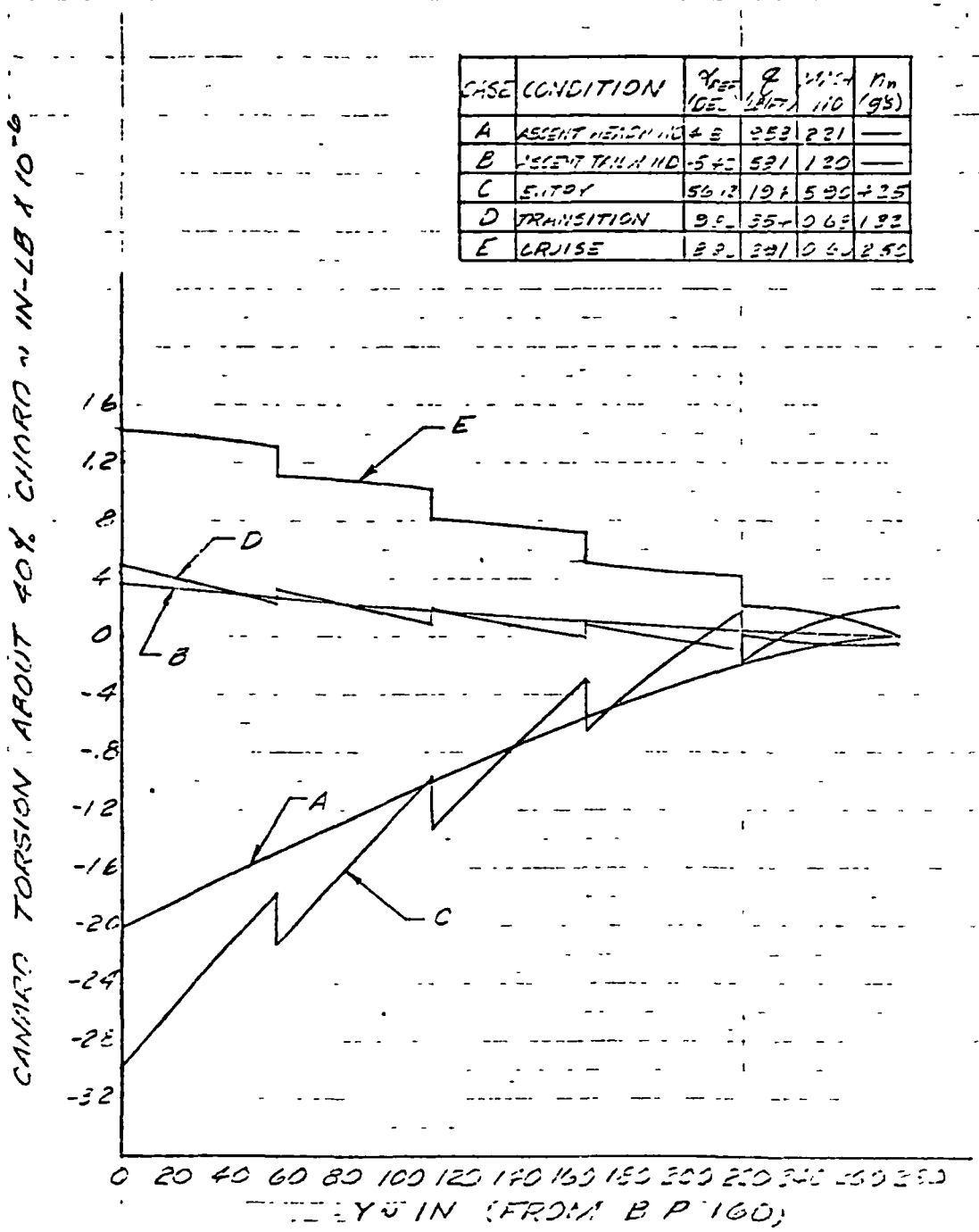

CONFIGURATION 20 B BOOSTER CANARD
NORMAL SHEAR - RIGID LOADS
CASE
CONDITION
A
B
C
D
E
CANARD NORMAL SHEAR ~LB X 10^-3
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
Y ~ IN (FROM B P 160)

CONFIGURATION 20B BOOSTER CANARD
BENDING MOMENT ~ RIGID LOADS



CONFIGURATION 20B BOOSTER CANARD
TORSION ~ RIGID LOADS

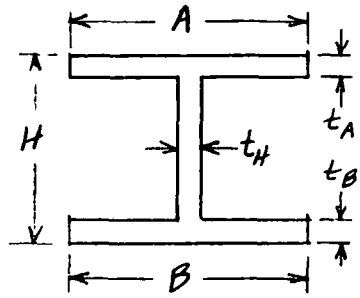
CASE	CONDITION	α_{REF} (DEG)	q (LB/FT²)	MACH NO	n_n (g's)
A	ASCENT HEADWIND	4.8	253	2.21	—
B	ASCENT TAILWIND	-5.40	531	1.20	—
C	ENTRY	56.12	194	5.90	4.25
D	TRANSITION	9.[illegible]	354	0.6[illegible]	1.32
E	CRUISE	8.[illegible]	391	0.6[illegible]	2.50



CANARD WEIGHT SUBSTANTIATION *

FRONT SPAR UPPER CHORD (2 PER BOOSTER)

SPAN STA.	t_A	A	t_B	B	t_H	H	UNIT AREA (IN.)
160	.82	5.0	.82	5.0	.41	4.5	9.50
175	.82	5.0	.82	5.0	.41	4.5	9.50
242.5	.41	5.0	.41	5.0	.21	4.5	4.74
297.5	.21	4.0	.21	4.0	.10	4.5	2.01
352.5	.125	3.0	.125	3.0	.08	4.0	1.05
407.5	.125	2.0	0	0	.08	1.0	.32
435	.125	2.0	0	0	.08	1.0	.32



MAT'L. 7075-T73511

$2(175-160)/3\left[9.50+9.50+\sqrt{9.50(9.50)}\right].101 = 28.8$
$2(242.5-175)/3\left[9.50+4.74+\sqrt{9.50(4.74)}\right].101 = 95.2$
$2(297.5-242.5)/3\left[4.74+2.01+\sqrt{4.74(2.01)}\right].101 = 36.4$
$2(352.5-297.5)/3\left[2.01+1.05+\sqrt{2.01(1.05)}\right].101 = 16.7$
$2(407.5-352.5)/3\left[1.05+.32+\sqrt{1.05(.32)}\right].101 = 7.2$
$2(435-407.5)/3\left[.32+.32+\sqrt{.32(.32)}\right].101 = 1.8$

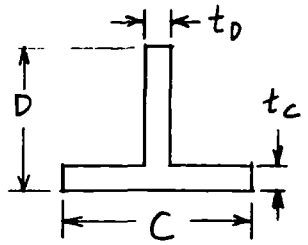
TOTAL WEIGHT = <u>186.1</u> LB. / BOOSTER

FRONT SPAR LOWER CHORD (2 PER BOOSTER)

SPAN STA.	t_C	C	t_D	D	UNIT AREA (IN.)
160	.81	5.0	.41	3.25	5.05
175	.81	5.0	.41	3.25	5.05
242.5	.5	5.0	.25	3.0	3.13
297.5	.25	4.0	.125	2.25	1.25
352.5	.16	3.0	.08	2.16	.64
407.5	.125	2.0	.08	1.0	.32
435	.125	2.0	.08	1.0	.32

* REFERENCE DRAWING MMC 899A2010639

FRONT SPAR LOWER CHORD (CONT'D.)



MAT'L. 7075-T73511

$2(175-160)/3\,[5.05+5.05+\sqrt{5.05\,(5.05)}\,].101 = 15.3$
$2(242.5-175)/3\,[5.05+3.13+\sqrt{5.05\,(3.13)}\,].101 = 55.2$
$2(297.5-242.5)/3\,[3.13+1.25+\sqrt{3.13\,(1.25)}\,].101 = 23.5$
$2(352.5-297.5)/3\,[1.25+.64+\sqrt{1.25\,(.64)}\,].101 = 10.3$
$2(407.5-352.5)/3\,[.64+.32+\sqrt{.64\,(.32)}\,].101 = 5.2$
$2(435-407.5)/3\,[.32+.32+\sqrt{.32\,(.32)}\,].101 = 1.8$

TOTAL WEIGHT = 111.3 LB. / BOOSTER

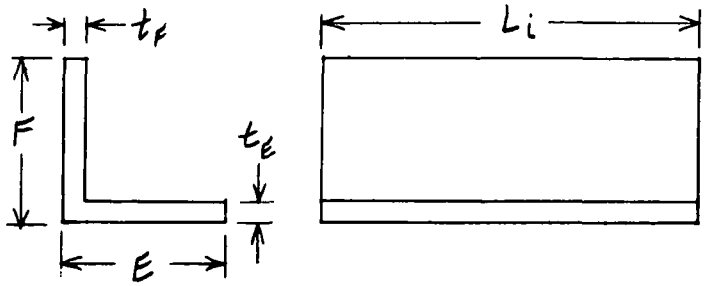
FRONT SPAR WEB (2 PER BOOSTER) MAT'L. 7075-T73

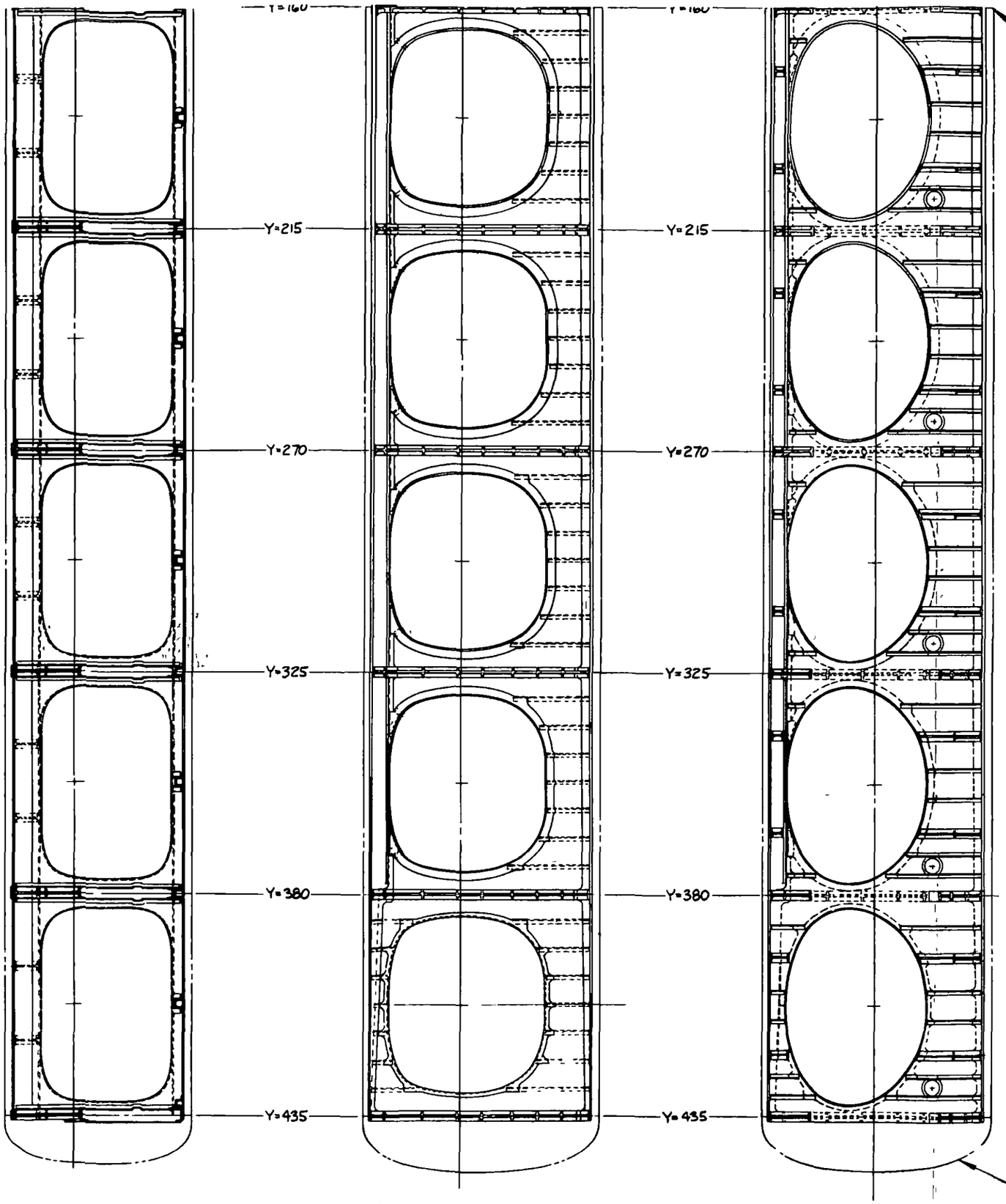
SPAN STA.	AVG. t	AVG. h	ENG. CUTOUT AREA (IN.)
160 - 215	.16	50.0	1644
215 - 270	.125	50.35	1600
270 - 325	.10	50.5	1582
325 - 380	.05	51.125	1566
380 - 435	.05	55.1	1544

$2[(215-160)50.0-1644].16\,(.101) = 35.7$
$2[(270-215)50.35-1600\,].125(.101) = 29.5$
$2[(325-270)50.5-1582].10\,(.101) = 24.1$
$2[(380-325)51.125-1566].05\,(.101) = 12.6$
$2[(435-380)55.1-1544].05\,(.101) = 15.0$
TOTAL WEIGHT = 116.9 LB / BOOSTER

FRONT SPAR WEB STIFFENERS

6.875 IN. SPACING MAT'L. 7075-T73511





SPAR CONFIGURATION

CANARD STRUCTURE ASSEMBLY CONFIGURATION 20B

E 04236 899A2010639

FRONT SPAR WEB STIFFENERS (CONT'D.)

SPAN STA.	E	t_E	F	t_F	L_1	N_1	L_2	N_2	(IN.)
160 – 215	1.0	.125	.875	.125	10.0	10	29.0	4	
215 – 270	1.0	.12	.82	.12	10.65	10	29.65	4	
270 – 325	1.0	.11	.77	.11	10.95	10	29.95	4	
325 – 380	.75	.09	.63	.09	11.2	10	30.2	4	
380 – 435	.75	.09	.63	.09	11.55	10	30.55	4	

$[10(10.0) + 4(29.0)][.125(1.0) + .125(.875 - .125)].101 = 4.8$
$[10(10.65) + 4(29.65)][.12(1.0) + .12(.82 - .12)].101 = 4.6$
$[10(10.95) + 4(29.95)][.11(1.0) + .11(.77 - .11)].101 = 4.2$
$[10(11.2) + 4(30.2)][.09(.75) + .09(.63 - .09)].101 = 2.7$
$[10(11.55) + 4(30.55)][.09(.75) + .09(.63 - .09)].101 = 2.8$

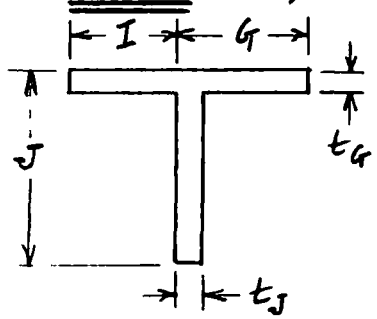
TOTAL WEIGHT = 19.1 LB. / BOOSTER

F.S. WEB ENGINE CUTOUT FLANGE (2 EA. PER BOOSTER)

SPAN STA.	t_G	G	I	t_J	J	LENGTH (IN.)
160 – 215	.75	2.19	1.81	.375	3.25	143
215 – 270	.4	2.125	1.875	.25	2.9	142.5
270 – 325	.25	2.06	1.94	.125	2.25	141.5
325 – 380	.16	1.54	1.46	.08	2.16	141.5
380 – 435	.06	.63	0	.06	.75	141

$2(143)[.75(2.19 + 1.81) + .375(3.25 - .75)].101 = 113.7$
$2(142.5)[.4(2.125 + 1.875) + .25(2.9 - .4)].101 = 64.0$
$2(141.5)[.25(2.06 + 1.94) + .125(2.25 - .25)].101 = 35.7$
$2(141.5)[.16(1.54 + 1.46) + .08(2.16 - .16)].101 = 18.3$
$2(141)[.06(.63 + 0) + .06(.75 - .06)].101 = 2.3$

TOTAL WEIGHT = 234.0 LB. / BOOSTER



MAT'L. 7075-T73511

REAR SPAR UPPER CHORD (2 PER BOOSTER)

SPAN STA.	t_A	A	t_B	B	t_H	H	UNIT AREA (IN.)
160	.53	5.0	.532	5.0	.20	4.5	5.99
175	.53	5.0	.532	5.0	.20	4.5	5.99
242.5	.40	5.0	.40	5.0	.16	4.5	4.59
297.5	.20	4.0	.20	4.0	.10	4.5	2.01
352.5	.10	3.0	.10	3.0	.06	4.0	.83
407.5	.10	2.0	0	0	.08	1.0	.27
435	.10	2.0	0	0	.08	1.0	.27

(SEE FRONT SPAR FOR SYMBOLS) MAT'L. 7075-T7351I

$2(175-160)/3\left[5.99+5.99+\sqrt{5.99(5.99)}\right].101 = 18.1$

$2(242.5-175)/3\left[5.99+4.59+\sqrt{5.99(4.59)}\right].101 = 71.9$

$2(297.5-242.5)/3\left[4.59+2.01+\sqrt{4.59(2.01)}\right].101 = 35.7$

$2(352.5-297.5)/3\left[2.01+.83+\sqrt{2.01(.83)}\right].101 = 15.3$

$2(407.5-352.5)/3\left[.83+.27+\sqrt{.83(.27)}\right].101 = 5.8$

$2(435-407.5)/3\left[.27+.27+\sqrt{.27(.27)}\right].101 = 1.5$

TOTAL WEIGHT = 148.3 LB. / BOOSTER

REAR SPAR LOWER CHORD (2 PER BOOSTER)

SPAN STA	t_C	C	t_D	D	UNIT AREA (IN.)
160	.53	5.0	.26	3.0	3.29
175	.53	5.0	.26	3.0	3.29
242.5	.40	5.0	.20	2.9	2.5
297.5	.25	4.0	.10	2.25	1.2
352.5	.16	3.0	.08	2.16	.64
407.5	.10	2.0	.08	1.0	.27
435	.10	2.0	.08	1.0	.27

(SEE FRONT SPAR FOR SYMBOLS) MAT'L. 7075-T7351I

$2(175-160)/3\left[3.29+3.29+\sqrt{3.29(3.29)}\right].101 = 10.0$

$2(242.5-175)/3\left[3.29+2.5+\sqrt{3.29(2.5)}\right].101 = 39.4$

$2(297.5-242.5/3\left[2.5+1.2+\sqrt{2.5(1.2)}\right].101 = 20.1$

$2(352.5-297.5)/3\left[1.2+.64+\sqrt{1.2(.64)}\right].101 = 10.1$

$2(407.5-352.5)/3\left[.64+.27+\sqrt{.64(.27)}\right].101 = 4.9$

$2(435-407.5)/3\left[.27+.27+\sqrt{.27(.27)}\right].101 = 1.5$

TOTAL WEIGHT = 86.0 LB. / BOOSTER

REAR SPAR WEB (2 PER BOOSTER) MAT'L. 7075-T73

SPAN STA.	AVG. t	AVG. h	ENG. CUTOUT AREA (IN.)
160 - 215	.16	48.75	1500
215 - 270	.112	48.85	1488
270 - 325	.08	49.0	1469
325 - 380	.05	49.59	1457
380 - 435	.05	53.64	1432

$2[(215-160)48.75-1500].16(.101) = 38.2$
$2[(270-215)48.85-1488].112(.101) = 27.1$
$2[(325-270)49.0-1469].08(.101) = 19.8$
$2[(380-325)49.59-1457].05(.101) = 12.8$
$2[(435-380)53.64-1432].05(.101) = 15.3$

TOTAL WEIGHT = 113.2 LB. / BOOSTER

REAR SPAR WEB STIFFENERS

6.875 IN. SPACING MAT'L 7075-T73511 (IN.)

SPAN STA.	E	t_E	F	t_F	L_1	N_1	L_2	N_2	L_3	N_3
160 - 215	1.0	.133	.95	.133	12.6	6	16.6	4	48.0	4
215 - 270	1.0	.112	.78	.112	12.8	6	16.8	4	48.2	4
270 - 325	1.0	.108	.76	.108	13.1	6	17.1	4	48.5	4
325 - 380	.75	.093	.65	.093	13.3	6	17.3	4	48.7	4
380 - 435	.75	.09	.63	.09	13.7	6	17.7	4	49.1	4

(SEE FRONT SPAR FOR SYMBOLS)

$[6(12.6)+4(16.6)+4(48.0)][.133(1.0)+.133(.95-.133)].101 = 8.2$
$[6(12.8)+4(16.8)+4(48.2)][.112(1.0)+.112(.78-.112)].101 = 6.4$
$[6(13.1)+4(17.1)+4(48.5)][.108(1.0)+.108(.76-.108)].101 = 6.1$
$[6(13.3)+4(17.3)+4(48.7)][.093(.75)+.093(.65-.093)].101 = 4.2$
$[6(13.7)+4(17.7)+4(49.1)][.09(.75)+.09(.63-.09)].101 = 4.1$

TOTAL WEIGHT = 29.0 LB. / BOOSTER

R.S WEB ENGINE CUTOUT FLANGE (2 PER BOOSTER)

SPAN STA	t_G	G	I	t_J	J	LENGTH (IN.)
160 - 215	.50	2.125	1875	.25	30	139
215 - 270	.40	2.1	1.9	.20	2.9	138.75
270 - 325	.25	2.05	1.95	.10	2.25	138.4
325 - 380	.16	1.54	1.46	.08	2.16	138.2
380 - 435	.06	.63	0	.06	.75	137.7

(SEE FRONT SPAR FOR SYMBOLS) MAT'L. 7075-T73511

2(139) [.50(2.125+1.875) + .25(3.0 - .50)] .101 = 73.7
2(138.75)[.40(2.1 + 1.9) + .20(2.9 - .40)] .101 = 58.9
2(138.4)[.25(2.05 + 1.95) + .10(2.25 - .25)] .101 = 33.5
2(138.2)[.16(1.54 + 1.46) + .08(2.16 - .16)] .101 = 17.9
2(137.7)[.06(.63 - 0) + .06(.75 - .06)] .101 = 2.2

TOTAL WEIGHT = 186.2 LB. / BOOSTER

ADDITIONAL SPAR CHORD MATERIAL FOR SKIN ATTACHMENT:

LOWER SKIN TO F.S. UPPER CHORD
WT = 2 [.05(270-160) + .04(435-270)] .101 (2) = 4.1 LB. / BOOSTER
UPPER SKIN TO R.S. UPPER CHORD - 4.9 LB. / "
LOWER PANELS TO F.S. LOWER CHORD - 4.9 LB. / "
LOWER PANELS TO R.S. LOWER CHORD 4.9 LB. / "
F.S. WEB TO F.S. UPPER CHORD
WT = 2(55)(.16 + .125 + .10) .101 (2) = 8.6 LB / BOOSTER
F.S. WEB TO F.S. LOWER CHORD = 8.6 LB. / "
R.S. WEB TO R.S. UPPER CHORD
WT = 2(55)(.16 + .112 + .08) .101 (2) = 7.5 LB. / BOOSTER
R.S. WEB TO R.S. LOWER CHORD - 7.8 LB. / "
F.S. UPPER SKIN TO F.S. UPPER CHORD
WT = 2 [.05(270-160) + .04(435-270)] .101 (2) = 5.0 LB. / BOOSTER
LOWER SKIN TO F.S. LOWER CHORD
WT = 2 (.04)(435-160) .101 (2) = 4.4 LB. / BOOSTER
F.S. UPPER SKIN TO R.S. UPPER CHORD
WT = 2 (.04)(435-160) .101 (2) = 4.4 LB. / BOOSTER
LOWER SKIN TO R.S. LOWER CHORD - 4.4 LB. / "

TOTAL WEIGHT F.S. = 36.4 LB / BOOSTER
TOTAL WEIGHT R.S. = 34.2 LB / BOOSTER

ADDITIONAL SPAR WEB MATERIAL FOR JOINTS, SPLICES & FASTENERS (JSF)

F.S. WEB : WT. = 10% (116.9) = 11.7 LB./BOOSTER
R.S. WEB : WT. = 10% (113.2) = 11.3 LB./ "

UPPER SKIN BETWEEN F.S. AND R.S. MAT'L. 7075-T73

t = .05", STA. 160 TO 270; .04", STA. 270 TO 435 C = 136"

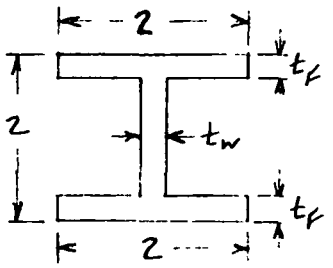
WT. = 2(136)[.05(270-160)+.04(435-270)].101 = 332.4 LB./BOOSTER

UPPER SKIN JSF

WT. = 5% (332.4) = 16.6 LB./BOOSTER

UPPER STRINGERS BETWEEN F.S. AND R.S. MAT'L. 7075-T73

SPAN STA.	t_f	t_w	NO./BAY	(IN.)
160-215	.10	.05	5	
215-270	.095	.05	5	
270-325	.085	043	5	
325-380	.07	.035	5	
380-435	.06	.03	5	

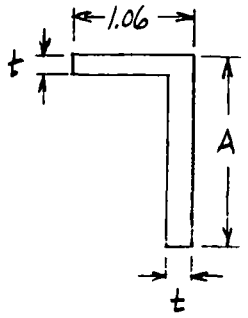


2(5)(215-160)[.10(2+2)+.05(2-.20)].101 = 27.2
2(5)(270-215)[.095(2+2)+.05(2-.19)].101 = 26.2
2(5)(325-270)[.085(2+2)+.043(2-.17)].101 = 23.2
2(5)(380-325)[.07(2+2)+.035(2-.14)].101 = 19.2
2(5)(435-380)[.06(2+2)+.03(2-.12)].101 = 16.4

TOTAL WEIGHT = 112.2 LB./BOOSTER

UPPER STRINGERS BETWEEN F.S. AND R.S. MAT'L. 7075-T73

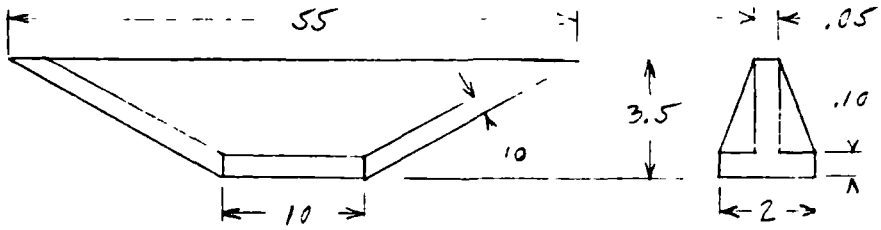
SPAN STA.	t	A	NO./BAY	(IN.)
160-270	.130	1.82	12	
270-435	.112	1.60	12	



2(12)(270-160).130(1.06+1.82-.13).101 = 95.4
2(12)(435-270).112(1.06+1.60-.112).101 = 114.2

TOTAL WEIGHT = 209.6 LB./BOOSTER

[illegible] FOR ENGINE [illegible] (10) [illegible] 7075-T73



WT. = 10[.10(10)2 + .05(3.5-.10)(55+10)/2 + √[(.55-10)/2]² + (4)²(2 [illegible]) 10 [illegible]
.101 = 12.1 LB./BOOSTER

UPPER STRINGERS JSF

WT = 3.5% (112 [illegible] + [illegible] + 12.1) = 18.4 [illegible]

RIBS [illegible] F.S. AND R.S. (12) MAT'L 7075-T73

[illegible] ON INB'D. & OUTB'D SURFACES FROM 2.5 IN [illegible]
WEB t = .05 IN., EXCEPT FOR .10 IN ABOVE ENG. TRUNNION PAD
[illegible] t = .125 IN., EXCEPT .16 IN. [illegible]
LOW. CHORD t = .06 IN UP. & LOW. CHORD WIDTH 2.5 IN.
[illegible] WIDTH, [illegible] .75 IN, [illegible]
[illegible] F.S. & R.S = 2.5 IN.
[illegible] STIFF. t = .125 IN, L = 54.5 IN. R.S. [illegible] IN, [illegible] IN
15 VERT STIFF @ t = .125 IN, L = 61.9 IN [illegible] VERT STIFF @ .16 IN., [illegible] 61.9 IN.
8 HORIZ. STIFF @ t = .125 IN, L = 13 IN. [illegible] HORIZ STIFF @ [illegible] IN, [illegible]
1 HORIZ STIFF @ t = .125 IN., L = 85.3 IN.
ADDED t FOR ENG TRUNNION PAD = .84 IN / RIB FACE OVER 42.2 [illegible] IN
RIB L = 141 IN. AVG H = 61.7 IN.
AVG RIB CHORD [illegible] = {4(2.5) + 2[2.5 - (2.5 - .05)/2]} ÷ [6(2.5)] = .837
AVG SPAR STIFFENER [illegible], SAME AS UP CHORD [illegible]
AVG INTERNAL STIFF. [illegible] = [4(1.75-.05) + 2(1.75-.05)/2] ÷ [illegible]
AVG ENG TRUNNION PAD FACTOR = [4(1) + 2 [illegible]] ÷ 6 = 5/6
ENG. TRUNNION PAD WT. INCL. IN PROPULSION GROUP = 33 LB/BOOSTER
UP CHORD WT. = .837(12)2.5[125(125.5) + .16(135)].101 = 45.3 LB.
LOW CHORD WT. = .837(12)2.5(.06)139(.101) 21.2 LB.
WEB WT. = 12[.05(141)61.7 + (.10-.05)135(85)].101 = 580.8 LB.
STIFFENER WT = 12[{.837(54.5+52.5)(2.5-.05) + 833[15(61.9) + 8(13) +
7(8) + 1(85.3)](1.75-.05)}.125 + 833(3)64.8(1.75-.075).16].101 =
337.6 LB
ENG. TRUNNION PAD WT. = 5/6(12)2(.84)42.2(.101) - 33 = 38.6 LB.
FILLETS, [illegible] AND FASTENERS = 42. LB

BODY ATTACHMENT MAT'L. 7075-T73

F.S. CHORDS, UPPER AND LOWER (2 EA. PER BOOSTER)

4.25 IN. WIDE X 2.25 IN. HIGH X 8 IN. LONG

2 STEEL BOLTS @ 1 IN. DIA. X 8.5 IN. LONG (INCL. NUT, WASH.)

$WT. = 2(2)[4.25(2.25)8 - 2(\pi/4)(1)^2 4.25].101 +$
$2(2)2(\pi/4)(1)^2 8.5(.283) = 28.2 + 15.2 = \underline{43.4}$ LB./ BOOSTER

R.S. CHORDS, UPPER AND LOWER (2 EA. PER BOOSTER)

3 IN. WIDE X 2 IN. HIGH X 7 IN. LONG

2 STEEL BOLTS @ 7/8 IN. DIA. X 6 IN. LONG (INCL. NUT, WASHER)

$WT. = 2(2)[3(2)7 - 2(\pi/4)(.875)^2 3].101 +$
$2(2)2(\pi/4)(.875)^2 6(.283) = 15.6 + 8.2 = \underline{23.8}$ LB./ BOOSTER

UPPER SKIN BETWEEN SPARS MAT'L. 7075-T73

2 SHEAR TIES PER BOOSTER, 141 IN. LONG, 2 IN. WIDE, $t = .05$ IN.

$WT. = 2(141)2(.05).101 +$ 2.0 LB. FOR FASTENERS =
$2.8 + 2.0 = \underline{4.8}$ LB./ BOOSTER

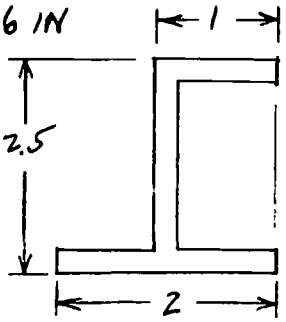
LOWER PANELS BETWEEN SPARS (10 PER BOOSTER)

STRUCTURAL FRAMEWORK

CHORDWISE EDGE MEMBERS (2 PER PANEL) 7075-T73

$L = 139.5$ IN.; $t = .06$ IN

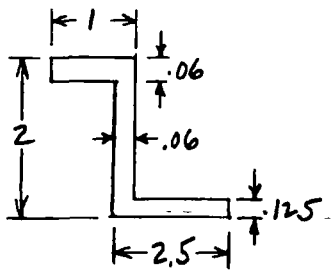
$WT. = 2(10)139.5(.06)(1+2.5+2-.12).101 =$
$\underline{91.}$ LB./ BOOSTER



SPANWISE EDGE MEMBERS (2 PER PANEL) 7075-T73

$L = 53.9$ IN.

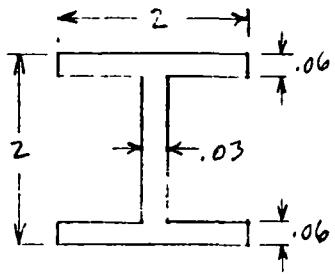
$WT. = 2(10)53.9[.125(2.5) + .06(1+2-.185)].101 =$
$\underline{52.}$ LB./ BOOSTER



LOWER PANELS STRUCTURAL FRAMEWORK (CONT'D.)

LATCH SUPPORT MEMBERS (5 PER PANEL) 7075-T73

L = 52 IN

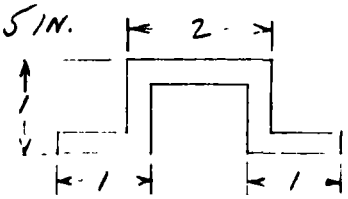


WT. = 5(10)52[.06(2+2)+.03(2-.12)].101 =

78. LB./BOOSTER

INTERMEDIATE SUPPORT MEMBERS (2 PER PANEL) 7075-T73

L = 52 IN.; t = .05 IN.

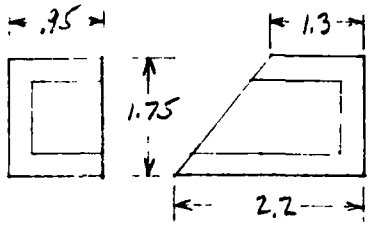


WT. = 2(10)52(.05)(1+1+2+1+1-.20).101 =

30. LB./BOOSTER

CORNER FITTINGS (18 PER PANEL) 7075-T73

t = .05 IN.



WT. = 18(10)[1.75(1.3+2.2)/2 + 1.75(.95-.05)+
(2.2+1.3-.10)(.95-.05)].05(.101) =

7. LB./BOOSTER

JOINTS, SPLICES AND FASTENERS (JSF)

WT. = 7.5%(91+52+78+30+7) = 19.4 LB./BOOSTER

TOTAL STRUCTURAL FRAMEWORK WT. = 277.4 LB./BOOSTER

LATCH MECHANISM

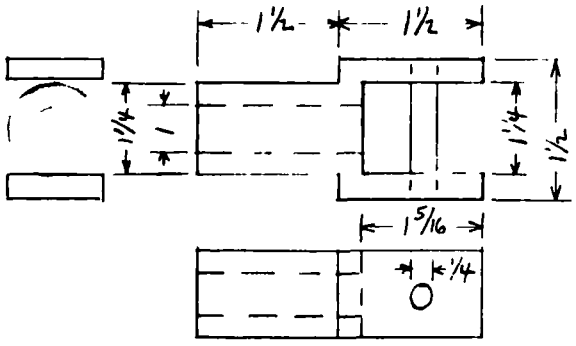
DRIVE SHAFTS (6 PIECES PER PANEL) ALUMINUM

1 IN. O.D. X 1/8 IN. WALL, TOTAL LENGTH = 113 IN.

WT. = 10(113)π/4[(1)² - (.75)²].101 = 39. LB/BOOSTER

DRIVE SHAFT UNIVERSAL JOINTS (4 PAIRS PER PANEL)

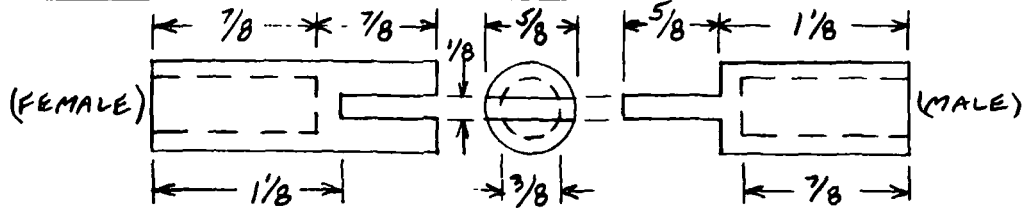
ALUMINUM BODIES, STEEL PINS



WT = 10(4)2[π/4(1¼)² 1.5 +
1.5(1.5)125 - π/4(1)² 1 11/16 -
1 5/16 (1.25)125 - π/4(¼)² ¼].101 +
10(4)2(π/4)(¼)² 1.5(.283) =
10 + 2 = 12. LB./BOOSTER

LOWER PANELS LATCH MECHANISM (CONT'D.)

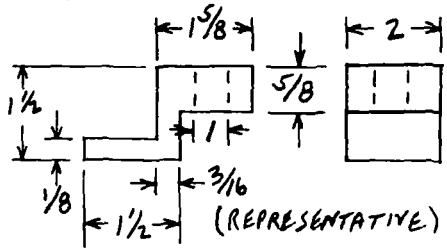
DRIVE SHAFT END FITTINGS (2 PAIRS PER PANEL) STEEL



WT. = 10 (2) π/4 [(5/8)² (1 3/4 + 1 3/4 - 5/8) - (3/8)² (7/8 + 7/8)] .283 =
4. LB./BOOSTER

DRIVE SHAFT BRACKETS (6 PER PANEL) ALUMINUM

WT. = 10 (6) [1 5/8 (2) 5/8 + 1 1/2 (2) 1/8 +
3/4 (2) 3/16 - π/4 (1)² 5/8] .101 =
13. LB./BOOSTER

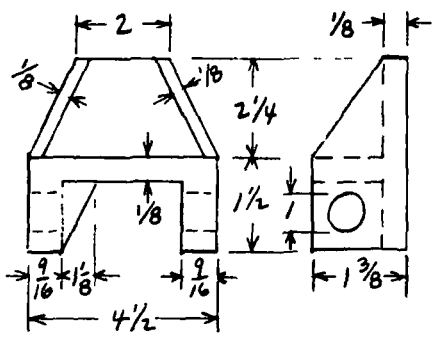


WORM GEARS (5 PER PANEL) STEEL
1 IN. O.D. X .20 IN. WALL X 10 IN. LENGTH

WT. = 10 (5) 10 (π/4) [(1)² - (.60)²] .283 = 71. LB./BOOSTER

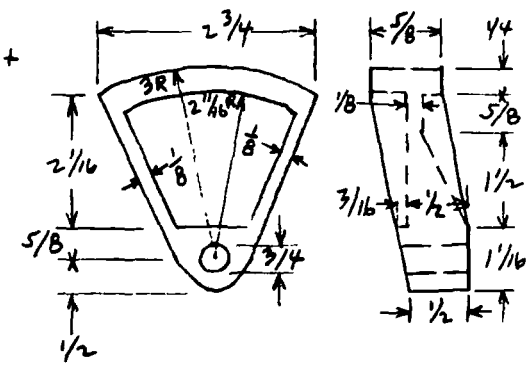
WORM GEAR BRACKETS (5 PER PANEL) ALUMINUM

WT. = 10 (5) [1/8 (2 1/4) (2 + 4 1/2)/2 +
2.8 (1 1/4) 1/8 + 1 1/2 (1 3/8) 1 1/8 +
1/8 (1 1/8) 1 3/8 /2 - π/4 (1)² 1 1/8] .101 =
15. LB./BOOSTER



GEAR SEGMENTS (5 PER PANEL) PHOSPHOR BRONZE

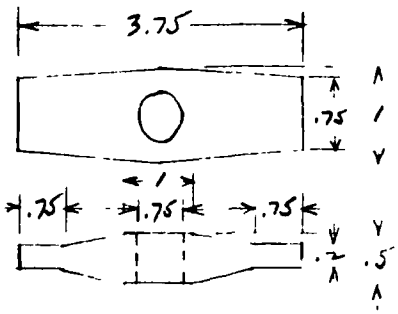
WT. = 10 (5) [(3 + 2 11/16) (2 3/4 + 1) 5/8 /4 +
π/2 (1/2)² 5/8 - π/4 (3/4)² 5/8 -
(1/4 + 3/16) 2 1/16 (2 1/2 + 1) /4 -
(5/8 + 2 1/16) 2 (1/4)/2] 318 =
27. LB. PER BOOSTER



LOWER PANELS LATCH MECHANISM (CONT'D.)

LINKS (5 PER PANEL) ALUMINUM

$WT. = 10(5)[2(.75).2(.8) + (.2+.5).625(1.9) + 1(.97).5 - \pi/4(.75)^2.5].101 =$ 7. LB./BOOSTER



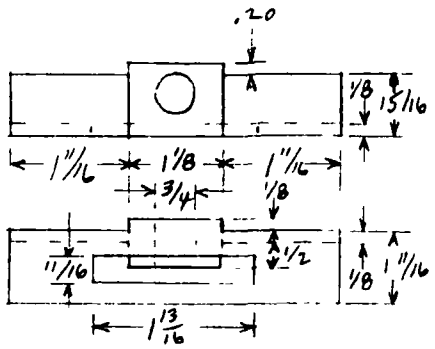
LINK PINS (5 PER PANEL) ALUMINUM

3/4 IN. DIA. X 1 7/8 LENGTH

$WT. = 10(5)\pi/4(3/4)^2 1\,7/8(.101) =$ 4. LB./BOOSTER

PIVOT BRACKETS (5 PER PANEL) ALUMINUM

$WT. = 10(5)[1/8(4\,1/2)(15/16 + 1\,''/16 - 1/8) + 1/8(1\,1/8)1.138 + 1/2(1\,1/8)1013 + .20(1/8)1\,1/8 - \pi/4(3/4)^2 3/4 - 1/8(11/16)1\,13/16].101 =$ 9 LB./BOOSTER



LOCKING DEVICE (1 PER PANEL) STEEL

1.35 IN. O.D. X 1 IN. I.D X 1.75 IN. LONG

2 SPRINGS @ 1.1 IN. O.D. X .0625 IN. GAGE X 10 COILS

$WT. = 10\{(\pi/4)[(1.35)^2 - (1)^2]1.75 + 2(\pi/4)(.0625)^2\pi(1.1)10\}.283 =$

$3. + 1. =$ 4. LB./BOOSTER

PUSH RODS (10 PER PANEL) ALUMINUM

1 IN. O.D. X .06 IN. WALL; 5 RODS @ 19 IN. LENGTH,
5 RODS @ 27 IN. LENGTH

$WT = 10(5)(19+27)\pi/4[(1)^2 - (.88)^2].101 =$ 41. LB/BOOSTER

PUSH ROD END FITTINGS (10 PER PANEL) ALUMINUM

$WT. = 10(10)[\pi/4(.75)^2 1.5 + 3/4(1).4 - \pi/4(.625)^2 1.2].101 =$

6. LB./BOOSTER

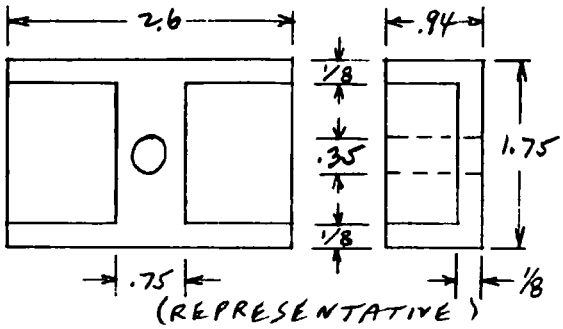
LATCH PINS (10 PER PANEL) STEEL

$WT. = 10(10)\pi/4(.35)^2 2.5(.283) =$ 7. LB./BOOSTER

LOWER PANELS LATCH MECHANISM (CONT'D.)

LATCH PIN GUIDES (10 PER PANEL) ALUMINUM

$WT. = 10(10)[2.6(.94)1.75 - 1.85(1.5).815 - \pi/4(.35)^2.94].101 =$
19. LB./BOOSTER.



LOCATING PINS (4 PER PANEL) STEEL

$WT. = 10(4)\pi/4(3/8)^2 1\,3/8(.283) =$ 2. LB./BOOSTER

LATCH PIN RETAINERS (10 PER PANEL) ALUMINUM

$WT. = 10(10)\pi/4[(.75)^2 2.5 - (.35)^2 1.1].101 =$ 10. LB./BOOSTER

TOTAL LATCH MECHANISM WT. = 290. LB./BOOSTER

LEADING EDGE (2 PER BOOSTER)

HOT TIP MAT'L HASTELLOY X

NOSE BEAM WEB

$t = .02$ IN., $H = 10$ IN., $L = 275$ IN

$WT. = 2(275)10(.02).297 =$ 32.6 LB./BOOSTER

NOSE TIP WEB

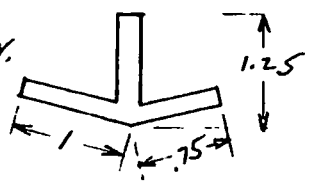
$t = .02$ IN., $H = 4$ IN., $L = 275$ IN.

$WT. = 2(275)4(.02).297 =$ 13. LB./BOOSTER

NOSE TIP LOWER CHORD

$L = 275$ IN., $t = .02$ IN.

$WT. = 2(275)(1.25+.75+1-.02).02(.297) =$
9.8 LB./BOOSTER



NOSE TIP SKINS, OUTER AND INNER (BEADED)

t (EACH) $= .04$ IN., $C = 21$ IN., $L = 275$ IN.

$WT. = 2(2)275(21).04(.297) =$ 274.4 LB./BOOSTER

NOSE BEAM INSULATION

$t = 1$ IN., $H = 7$ IN., $L = 275$ IN., $\rho = .002$ LB./CU. IN

$WT. = 2(275)7(1).002 =$ 7.8 LB./BOOSTER

LEADING EDGE HOT TIP (CONT'D.)

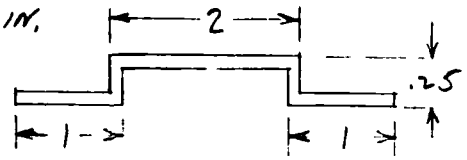
METAL BRUSH SEAL

.005 IN. DIA. WIRES, 10,000/SQ.IN., 1/4 IN. DEEP, 2 IN. WIDE, 275 IN. LONG

WT. = 2(275) 2 (1/4) 10,000 (π/4) (.005)². 297 = 16. LB/BOOSTER

SEAL HOLDER

L = 275 IN.; t = .02 IN.



WT. = 2(275)(1+.25+2+.25+1-.08)× .02 (.297) =

14.2 LB./BOOSTER

JSF WT. = 15% (32.6 + 13 + 9.8 + 274.4 + 7.8 + 16 + 14.2) =

.15(367.8) = 55.2 LB./BOOSTER

TOTAL L.E. HOT TIP WT. = 423 LB./BOOSTER

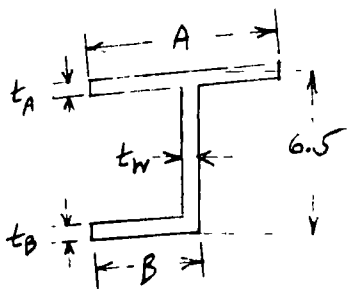
MAIN STRUCTURE

FRONT BEAM UPPER CHORD

ALUMINUM

SPAN STA.	t_A	A	t_B	B	t_w
160	.125	2.25	.25	1.125	.05
435	.06	2	.125	1	.03

	SECTION AREA
160	.87
435	.435



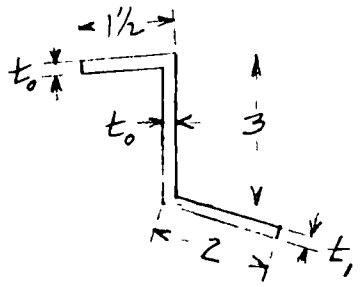
WT. = 2 (435-160)/3 [.87+.435+√(.87(.435))] .101 =

35.6 LB./BOOSTER

FRONT BEAM LOWER CHORD

ALUMINUM

SPAN STA.	t_0	t_1	SECT. AREA
160	.25	.125	1.28
435	.125	.06	.66



WT. = 2 (435-160)/3 [1.28+.66+√(1.28(.66)] .101 =

53. LB./BOOSTER

L.E. MAIN STRUCTURE (CONT'D.)

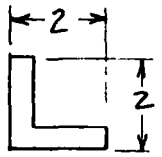
FRONT BEAM WEB — ALUMINUM

$t = .04$ IN., $H = 42$ IN., $L = 275$ IN.
CUTOUT AREA FOR 5 ENGINES PER SIDE = 7,445 SQ. IN.
1 IN. BENT-UP FLANGES AT CUTOUTS, $L = 5(144) = 720$ IN.

$WT. = 2[275(42) - 7445 + 1(720)].04(.101) =$ 39. LB./BOOSTER

FRONT BEAM WEB STIFFENERS (10 PER SIDE) ALUMINUM

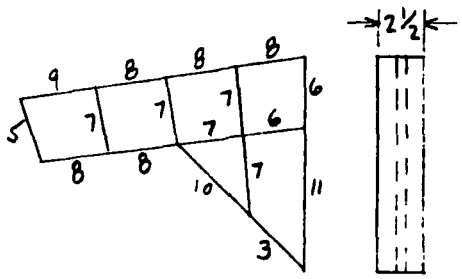
$L = 40$ IN., $t = .03$ IN



$WT. = 2(10)\,40(2+2-.03).03(.101) =$
9.6 LB./BOOSTER

FRONT RIBS (6 PER SIDE) — ALUMINUM

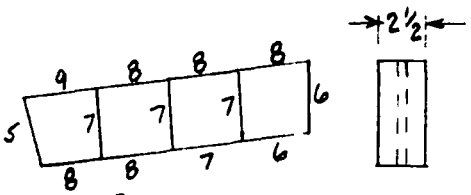
MACHINE FROM 2½ IN. PLATE
WEB $t = .03$ IN.
STIFFENER $t = .08$ IN.



$WT. = 2(6)\{[31(6.4) + 5.5(11.8)].03 + [125(2.5-.03)].08\}.101 =$
39.6 LB./BOOSTER

FRONT UPPER FORMERS (10 PER SIDE) — ALUMINUM

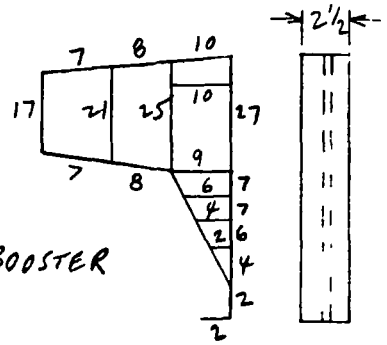
MACHINE FROM 2½ IN. PLATE
WEB $t = .03$ IN
STIFFENER $t = .08$ IN.



$WT. = 2(10)[31(6.4).03 + 94(2.5-.03).08].101 =$ 49.6 LB./BOOSTER

REAR RIBS (6 PER SIDE) — ALUMINUM

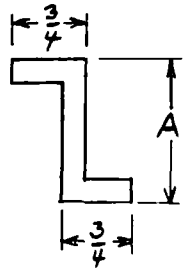
MACHINE FROM 2½ IN. PLATE
WEB $t = .04$ IN.
STIFFENER $t = .09$ IN.



$WT. = 2(6)\{[24.5(22.5) + 24(4.2)].04 +$
$219(2.5-.04).09\}.101 =$ 90.4 LB./BOOSTER

L.E. MAIN STRUCTURE (CONT'D.)

LOWER FORMERS (46 PER SIDE) ALUMINUM



6.11 IN. SPACING; t = .04 IN., L = 23 IN.
A @ FRONT END = 2 IN.
A @ REAR END = 4 IN.
SECT. AREA @ FRONT END = $.04(\frac{3}{4}+2+\frac{3}{4}-.08)$ = .137 SQ. IN.
SECT AREA @ REAR END = $.04(\frac{3}{4}+4+\frac{3}{4}-.08)$ = .217 SQ. IN

WT. = $2(46)\,23/3\,[.137+.217+\sqrt{.137(.217)}\,].101$ = 37.5 LB./BOOSTER

LOWER FORMER CLIPS (92 PER SIDE) ALUMINUM

WT. = 2(92) 27 SQ. IN. (.04) .101 = 20. LB./BOOSTER

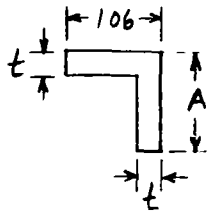
UPPER SKIN (1 PER SIDE) ALUMINUM

t, STA. 160 TO 270 = .05 IN C = 58 IN.
t, STA. 270 TO 435 = .04 IN.

WT. = $2(58)[.05(270-160)+.04(435-270)].101$ = 141.8 LB./BOOSTER

UPPER STRINGERS (5 PER SIDE) ALUMINUM

SPAN STA.	t	A
160 - 270	.130	1.82
270 - 435	.112	1.60



WT. = $2(5)[(270-160)(1.06+1.82-.13).13+$
$(435-270)(1.06+1.60-.112).112].101$ = 87.3 LB./BOOSTER

LOWER SKIN (1 PER SIDE) ALUMINUM

t = .04 IN., C = 24 IN., L = 275 IN.
WT. = $2(275)\,24\,(.04).101$ = 53.4 LB./BOOSTER

UPPER INNER CORRUGATION (END OF AIR DUCT) (1 PER SIDE)

TITANIUM t @ STA. 160 = .006 IN. t @ STA. 435 = .004 IN.
C = 10 IN. FORM FACTOR = 2.48

WT. = $2(10)(2.48)(435-160)/6\,[.006+.004+2(.006+.004)].163$ =
11.1 LB./BOOSTER

JSF WT. = 14 % (35.6 + 53 + 39 + 96 + 39.6 + 49.6 + 90.4 + 37.5 +
20 + 141.8 + 87.3 + 53.4 + 11.1) = .14(667.9) =
93.5 LB./BOOSTER

TRAILING EDGE (2 PER BOOSTER)

UPPER SKIN (1 PER SIDE)

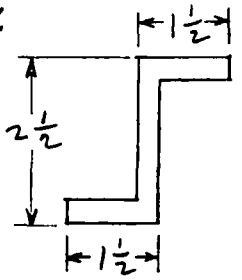
SECTION	MAT'L.	t	C
FRONT	ALUM.	.04	7
REAR	TITAN.	.02	12

L = 275 IN.

WT. = 2(275)[.04(7).101 + .02(12).163] = 37. LB./BOOSTER

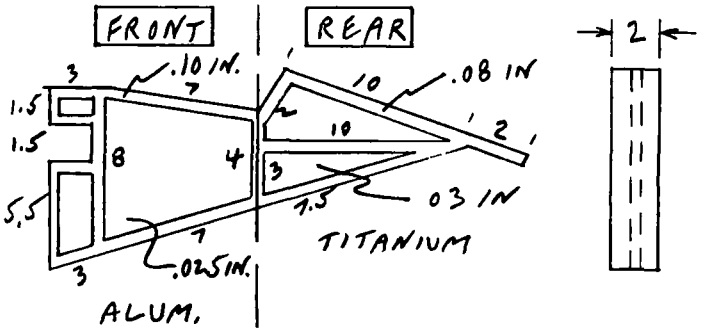
UPPER STRINGER (1 PER SIDE) TITANIUM

L = 275 IN.; t = .04 IN.



WT. = 2(275)(1½ + 2½ + 1½ - .08).04(.163) =
19.4 LB./BOOSTER

UPPER FRONT RIBS (6 PER SIDE) ALUMINUM



WT. = 2(6){[1.5(3) + 5(3) + 6(7)].025 + 46.5(2 - .025).10}.101 =
13. LB./BOOSTER

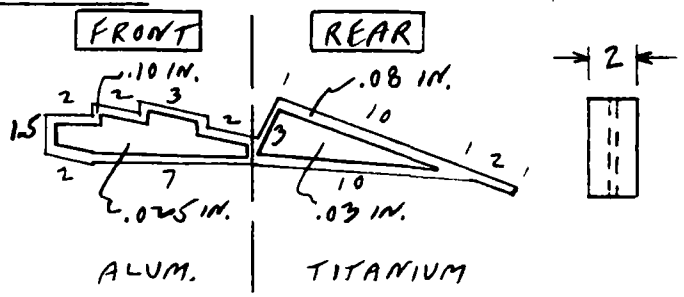
UPPER REAR RIBS (6 PER SIDE) TITANIUM

(REFER TO PRECEDING SKETCH)

WT. = 2(6){[1(10) + 1.5(7)].03 + 34.5(2 - .03).08}.163 =
11.8 LB./BOOSTER

TRAILING EDGE (CONT'D.)

UPPER FRONT FORMERS (10 PER SIDE) ALUMINUM



WT. = 2(10)[1.5(9).025 + 20(2-.025).10].101 = 8.6 LB./BOOSTER

UPPER REAR FORMERS (10 PER SIDE) TITANIUM

(REFER TO PRECEDING SKETCH)

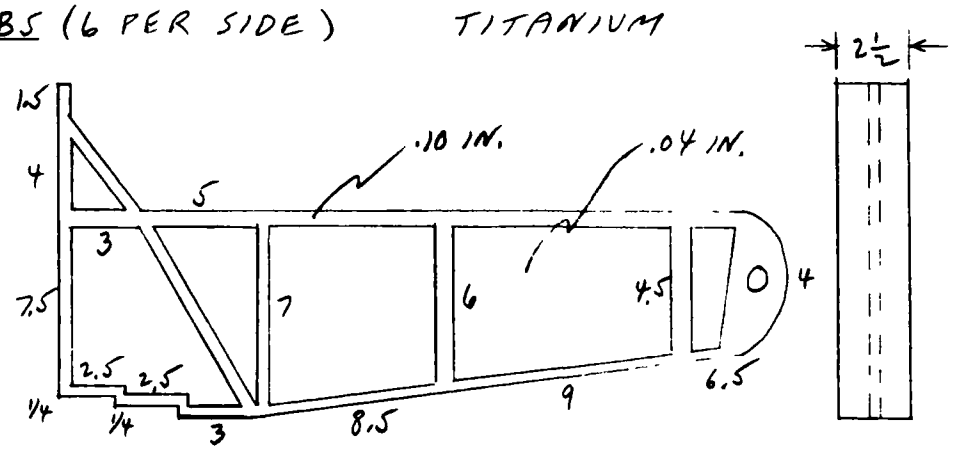
WT. = 2(10)[15(10).03 + 25(2-.03).08].163 = 14.4 LB./BOOSTER

LOWER SKIN (1 PER SIDE) TITANIUM

t = .02 IN., C = 32 IN., L = 275 IN.

WT. = 2(275)32(.02).163 = 57.4 LB./BOOSTER

LOWER RIBS (6 PER SIDE) TITANIUM

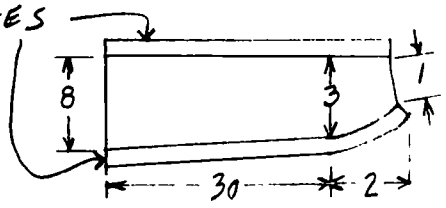


WT. = 2(6){[2(3) + 6(32)].04 + 113(2.5-.04).10 + π/4(4)²2.5}.163 = 128.8 LB/BOOSTER

LOWER FORMERS (10 PER SIDE) TITANIUM

1 IN. FLANGES

WT. = 2(10)32(7.3).05(.163) = 38.1 LB./BOOSTER

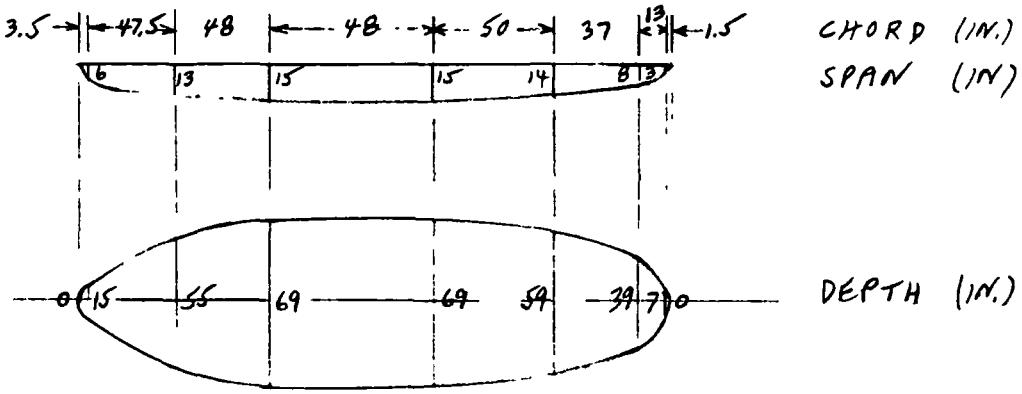


TRAILING EDGE (CONT'D.)

JSF WT. = 15% (37 + 19.4 + 13 + 11.8 + 8.6 + 14.4 + 57.4 + 128.8 + 38.1) = .15(328.5) = 50.5 LB./BOOSTER

TOTAL TRAILING EDGE WT. = 379. LB./BOOSTER

TIP (2 PER BOOSTER) ALUMINUM



SKIN (1 PER TIP)

t = .025 IN., WETTED AREA = 19,421 SQ.IN./TIP

WT. = 2(19,421) 025(.101) = 98. LB./BOOSTER

SPANWISE RIBS (10 PER TIP)

22.5 IN. SPACING, t = .02 IN., TOTAL AREA = 7,776 SQ.IN./TIP

WT. = 2(7,776).02(.101) = 31.4 LB./BOOSTER

BASE RIB (1 PER TIP)

t = .025 IN., AREA = 10,683 SQ.IN./TIP

WT. = 2(10,683).025(.101) = 54. LB./BOOSTER

JSF WT. = 15% (98 + 31.4 + 54) = .15(183.4) = 27.6 LB./BOOSTER

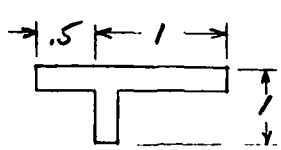
TOTAL TIP WT. = 211. LB./BOOSTER

INLET LIP (2 PER BOOSTER)

HOT TIP HASTELLOY X

NOSE BEAM UPPER CHORD (1 PER SIDE)

L = 275 IN.; t = .02 IN.



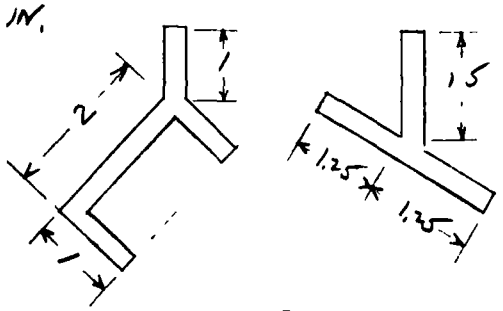
WT. = 2(275)(.5+1+1-.02).02(.297) =

8.2 LB./BOOSTER

INLET LIP HOT TIP (CONT'D.)

NOSE BEAM LOWER CHORDS (1 EACH PER SIDE)

L = 275 IN.; t = .02 IN.



WT. = 2(275)[(1+2+1+1−.04) + (1.25+1.25+1.5)].02(.297) =
29.2 LB./BOOSTER

NOSE BEAM WEB (1 PER SIDE)

t = .02 IN., H = 5.5 IN., L = 275 IN.

WT. = 2(275)5.5(.02).297 = 18. LB./BOOSTER

SKINS, OUTER AND INNER (BEADED) (1 EACH PER SIDE)

t = .04 IN. EACH, C = 12 IN, L = 275 IN,

WT. = 2(2)275(12).04(.297) = 156.8 LB./BOOSTER

NOSE BEAM INSULATION (1 PER SIDE)

t = 1 IN., H = 7.5 IN., L = 275 IN., ρ = .002 LB./CU.IN.

WT. = 2(275)7.5(1).002 = 8.2 LB./BOOSTER

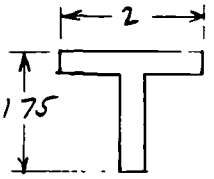
JSF WT. = 15% (8.2+29.2+18+156.8+8.2) = .15(220.4) =
33.1 LB./BOOSTER

TOTAL INLET LIP HOT TIP WT. = 253.5 LB/BOOSTER

MAIN STRUCTURE (EXCLUDING HINGE AND CONTROL FITTINGS WHICH ARE INCLUDED WITH ENGINE AIR INDUCTION SYSTEM)

SPAR CHORDS, UPPER AND LOWER (1 EACH/SIDE.) ALUMINUM

t = .06 IN @ STA. 435 TAPERING TO .135 IN. @ STA 160



WT. = 2(2)(435−160)(2+1.75−.0975).0975(.101) =
39.6 LB./BOOSTER

SPAR WEB (1 PER SIDE) ALUMINUM

t = .032 IN. @ STA. 435 TAPERING TO .072 IN. @ STA. 160. H = 11 IN.

WT. = 2(435−160)11(.052).101 = 31.8 LB./BOOSTER

INLET LIP MAIN STRUCTURE (CONT'D.)

SPAR WEB STIFFENERS (35 PER SIDE) ALUMINUM

SECTION AREA = .16 SQ. IN. @ STA. 160 TAPERING TO .08 SQ. IN. @ STA. 435. 6.11 IN. SPACING, H = 11 IN.

WT. = 2(35) 11 (.12) .101 = 9.4 LB./BOOSTER

UPPER SKIN (1 PER SIDE) TITANIUM

t = .009 IN. @ STA. 160 TAPERING TO .006 IN. @ STA. 435

C = 26 IN.

WT. = 2(435-160) 26 (.0075) .163 = 17.4 LB./BOOSTER

UPPER CORRUGATION (1 PER SIDE) TITANIUM

t = .006 IN. @ STA. 160 TAPERING TO .004 IN. @ STA. 435

C = 26 IN, FORM FACTOR = 2.48

WT. = 2(435-160) 26 (2.48) .005 (.163) = 29. LB./BOOSTER

LOWER FRONT SKIN (1 PER SIDE) TITANIUM

t = .009 IN. @ STA. 160 TAPERING TO .006 IN. @ STA. 435

C = 16.5 IN.

WT. = 2(435-160) 16.5 (.0075) .163 = 11. LB./BOOSTER

LOWER FRONT CORRUGATION (1 PER SIDE) TITANIUM

t = .006 IN. @ STA 160 TAPERING TO .004 IN. @ STA. 435

C = 16.5 IN. FORM FACTOR = 2.48

WT. = 2(435-160) 16.5 (2.48) .005 (.163) = 18.4 LB./BOOSTER

LOWER REAR SKIN (1 PER SIDE) ALUMINUM

t = .05 IN. FROM STA. 160 TO 270, = .04 IN. FROM STA. 270 TO 435

C = 16.5 IN.

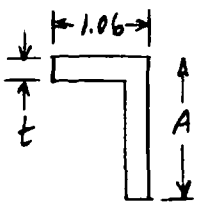
WT. = 2(16.5) [.05 (270-160) + .04 (435-270)] .101 =

40.4 LB./BOOSTER

LOWER REAR CHORD (1 PER SIDE) ALUMINUM

t = .13 IN. FROM STA. 160 TO 270, A = 1.82 IN.

t = .112 IN. " " 270 TO 435, A = 1.60 IN.



WT. = 2 [.13 (270-160) (1.06 + 1.82 - .13) +
.112 (435-270) (1.06 + 1.60 - .112)] .101 =

17.6 LB./BOOSTER

INLET LIP MAIN STRUCTURE (CONT'D.)

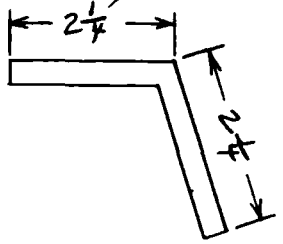
TRAILING EDGE SKIN (1 PER SIDE) ALUMINUM

$t = .025$ IN., $C = 14$ IN., $L = 275$ IN.

WT. $= 2(275)14(.025)(.101) =$ 19.4 LB./BOOSTER.

TRAILING EDGE UPPER CHORD (1 PER SIDE) ALUM.

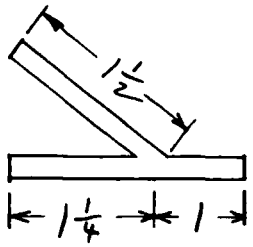
$L = 275$ IN., $t = .06$ IN.



WT. $= 2(275)(2.25+2.25-.06).06(.101) =$
14.8 LB./BOOSTER

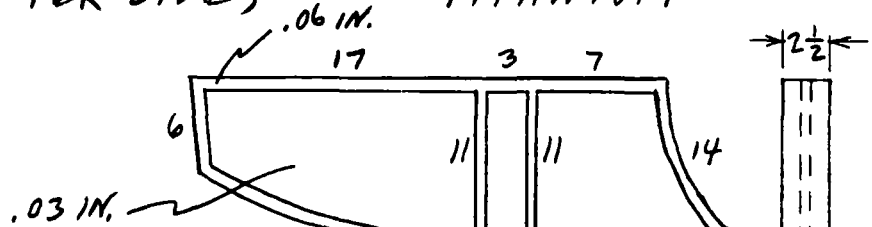
TRAILING EDGE LOWER CHORD (1 PER SIDE) ALUM.

$L = 275$ IN.; $t = .06$ IN.



WT. $= 2(275)(1.5+1.25+1-.06).06(.101) =$
12.2 LB./BOOSTER

MAIN RIBS (6 PER SIDE) TITANIUM

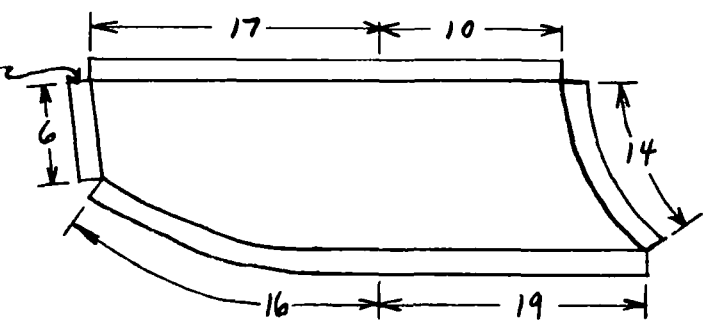


WT. $= 2(6)[31(11).03 + 104(2.5-.03).06].163 =$ 50.2 LB./BOOSTER

INTERMEDIATE RIBS (5 PER SIDE) TITANIUM

$t = .03$ IN.

1 IN. FLANGES



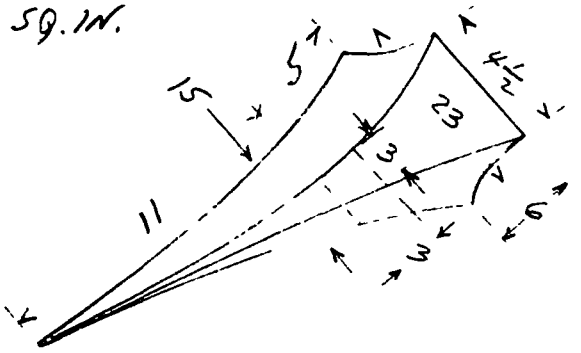
WT. $= 2(5)[31(11) + 82(1)].03(.163) =$ 20.6 LB./BOOSTER

INLET LIP MAIN STRUCTURE (CONT'D.)

RAMPS FOR ENGINE AIR INLET DUCTS (5 PER SIDE) TITANIUM

WETTED AREA - 259 SQ.IN.

t = .06 IN.



WT. = 2(5)259(.06).163 = 25.4 LB/BOOSTER

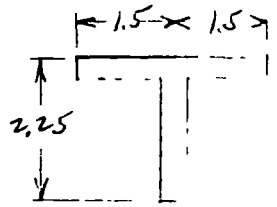
JSF WT. = 15% (39.6 + 31.8 + 9.4 + 17.4 + 29 + 11 + 18.4 + 40.4 + 17.6 + 19.4 + 14.8 + 12.2 + 50.2 + 23.6 + 15.4) = .15(357.2) = 53.6 LB. / BOOSTER

JET FLAP (10 PER BOOSTER) L605

MAIN STRUCTURE

SPAR UPPER CHORD (1 PER FLAP)

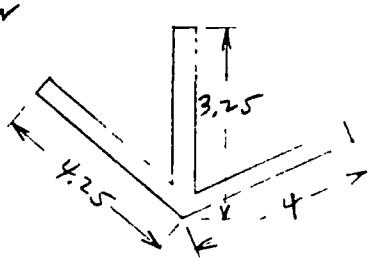
.1 SQ.IN. MIN. AREA, t = .02 IN, L = 49 IN.



WT. = 10(49)(1.5+1.5+2.25-.02).02(.330) = 17. LB./BOOSTER

SPAR LOWER CHORD (1 PER FLAP)

.1 SQ.IN. MIN. AREA, t = .02 IN., L = 49 IN

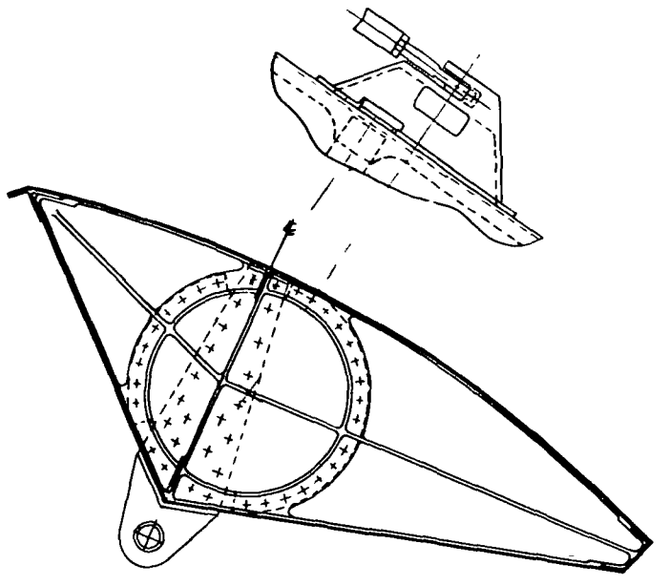


WT. = 10(49)(4.25+4+3.25-.02).02(.330) = 37. LB./BOOSTER

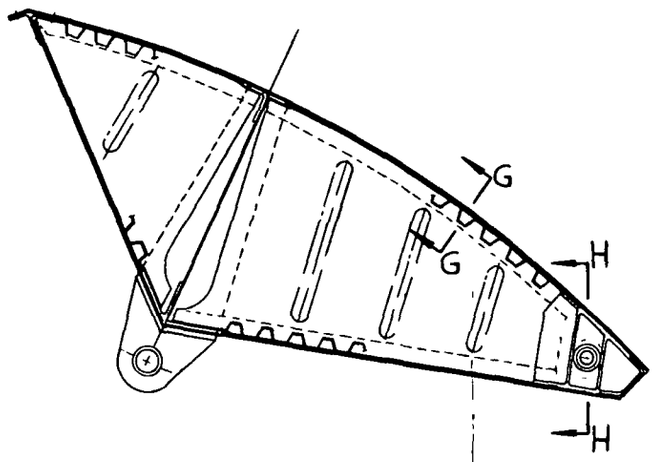
SPAR WEB (1 PER FLAP)

t = .02 IN., L = 49 IN., H = 17 IN

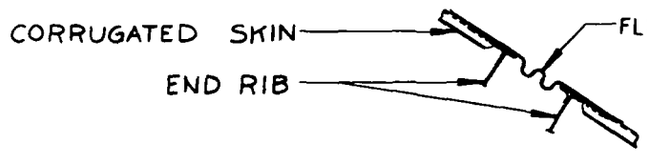
WT. = 10(49)17(.02).330 = 55. LB./BOOSTER



SECTION K-K
SCALE 1/4

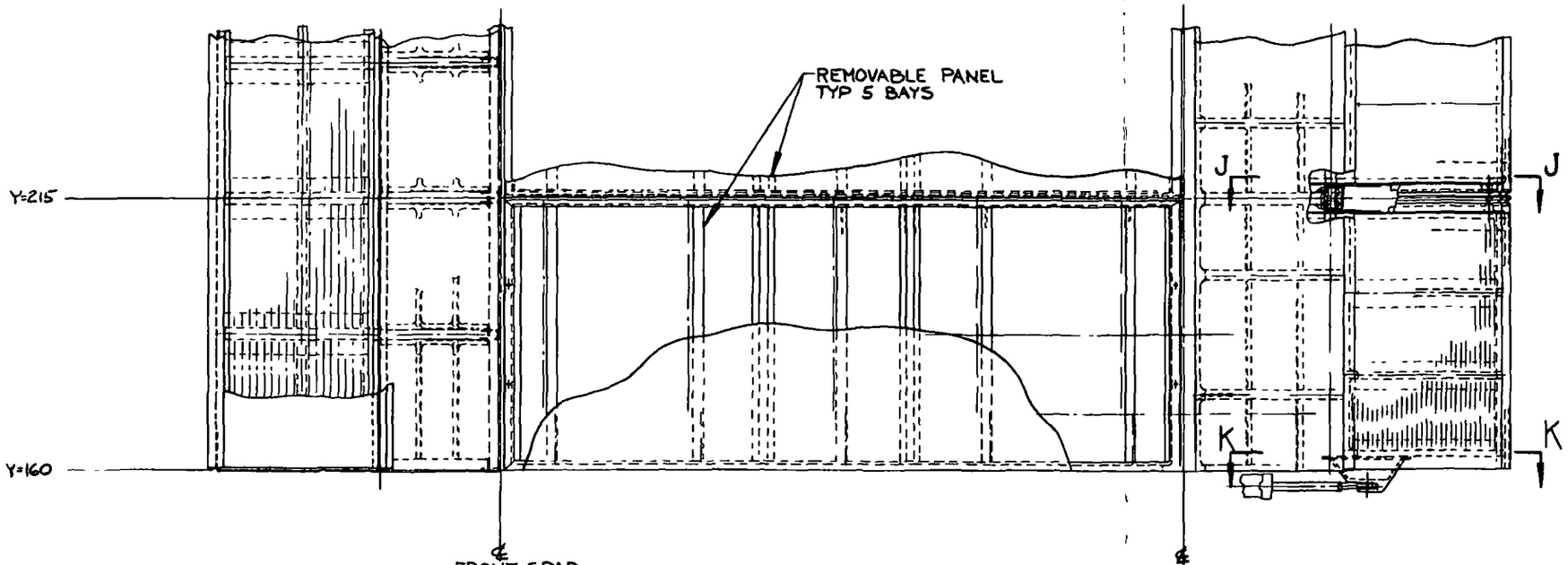


SECTION J-J
SCALE 1/4



SECTION G-G
SCALE 1/4

SECTION H-H
SCALE 1/4



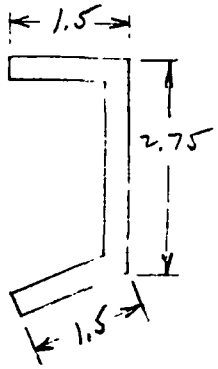
LOWER SURFACE
(TPS REMOVED)

D HASER 0935 6-8-71	MARTIN MARIETTA CORPORATION		
	CANARD STRUCTURE ASSEMBLY CONFIGURATION 20B		
	E 04236	899A2010639	
	No of NOTED		3

LIFT FLAP MAIN STRUCTURE (CONT'D)

TRAILING EDGE MEMBER (1 PER FLAP)

L = 50 IN., t = .025 IN.



WT. = 10 (50)(1.5+2.75+1.5-.05).025(.330) =
24. LB./BOOSTER

UPPER SKIN (1 PER FLAP)

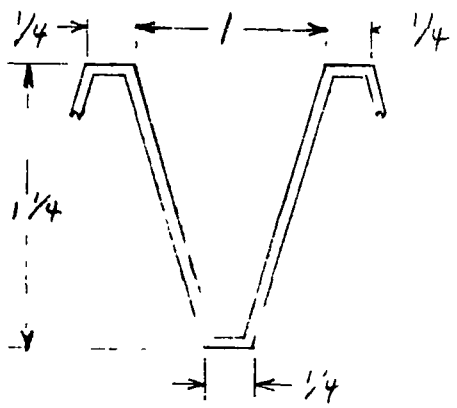
t = .012 IN., C = 55 IN., L = 50 IN.

WT. = 10(50)55(.012).330 = 109. LB/BOOSTER

UPPER CORRUGATION (1 PER FLAP)

t = .008 IN., C = 47 IN., L = 47 IN.

FORM FACTOR = 2.48



WT. = 10(47)47(2.48).008(.330) =
145. LB./BOOSTER

LOWER SKIN (1 PER FLAP)

t = .012 IN., C = 34 IN., L = 50 IN.

WT. = 10(50)34(.012).330 = 67. LB./BOOSTER

LOWER CORRUGATION (1 PER FLAP)

t = .008 IN., C = 30 IN., L = 47 IN., FORM FACTOR = 2.48

WT. = 10(47)30(2.48).008(.330) = 92. LB./BOOSTER

IRON - SKIN (1 PER FLAP)

t = .012 IN., C = 24 IN., L = 50 IN.

WT. = 10(50)24(.012).330 = 48. LB./BOOSTER

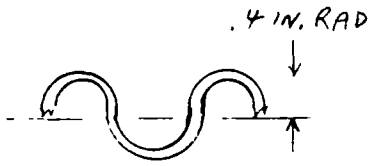
IRON - CORRUGATION (1 PER FLAP)

t = .008 IN., C = 20 IN., L = 47 IN., FORM FACTOR = 2.48

WT. = 10(47)20(2.48).008(.330) = 62. LB./BOOSTER

JET FLAP MAIN STRUCTURE (CONT'D)

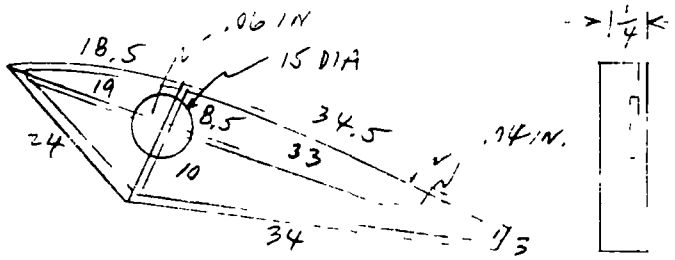
FLEXIBLE SKIN (4/5 EACH PER FLAP)



t = .02 IN, L = 6 IN.
FORM FACTOR = 1.57
C, UPPER = 55 IN.
C, LOWER = 34 IN.
C, FRONT = 24 IN.

WT. = (10) 4/5 (6) 1.57 (55+34+24) .02 (.330) = 56. LB / BOOSTER

DRIVE RIB (2/5 PER FLAP)

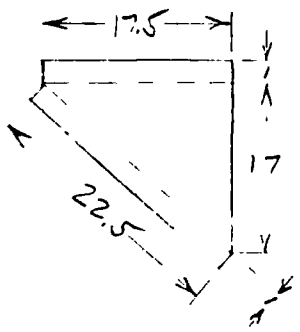


$$WT = 10(2/5)\{[17.75(4.25) + 12(7.25) + 33(6) + 33(5) + \{\pi(15) + 18.0 + 34.5 + 3 + 24 + 24 - 19 + 33 + 8.5 + 10\} \times (1.25 - .04)].04 + \pi/4 (15)^2 (.04 - .02)\}.330 =$$

49. LB BOOSTER

HINGE RIB FRONT WEB (8/5 PER FLAP)

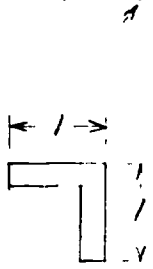
t = .04 IN



WT. = 10 (8/5) [17 (17.5/2) + (17.5 + 22.5) 1] x .04 (330) = 40. LB. / BOOSTER

HINGE RIB FRONT UPPER CHORD (8/5 PER FLAP)

L = 17.5 IN, t = .04 IN



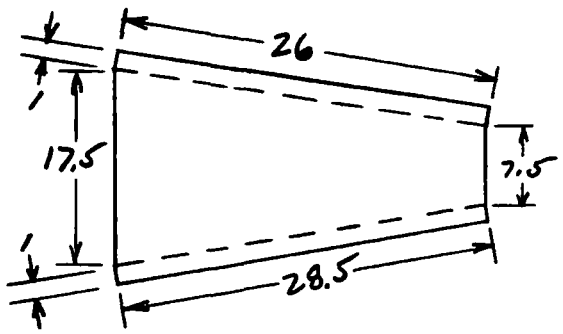
WT. = 10 (17.5) (1 + 1 - .04) .04 (.330) 8/5 =

7. LB. / BOOSTER

JET FLAP MAIN STRUCTURE (CONT'D.)

HINGE RIB REAR WEB (8/5 PER FLAP)

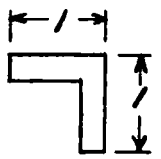
t = .04 IN.



WT. = 10 (8/5)[26 (17.5+7.5)/2 + (26+28.5) 1].04 (.330) =
80. LB./BOOSTER.

HINGE RIB REAR UPPER AND LOWER CHORDS (8/5 EA./FLAP)

t = .04 IN. UPPER L = 27 IN.
LOWER L = 28.5 IN.



WT. = 10 (8/5)(27+28.5)(1+1-.04).04 (.330) = 23. LB./BOOSTER

INTERMEDIATE FRONT RIBS (2 PER FLAP)

(SAME PATTERN AS HINGE RIB FRONT WEB)
t = .02 IN.

WT. = 10 (2) 189 SQ.IN. (.02). 330 = 25. LB./BOOSTER

INTERMEDIATE REAR RIBS (2 PER FLAP)

(SAME PATTERN AS HINGE RIB REAR WEB)
t = .025 IN.

WT. = 10 (2) 380 SQ.IN. (.025). 330 = 63. LB./BOOSTER

JSF WT. = 15% (17 + 37 + 55 + 24 + 109 + 145 + 67 + 92 +
48 + 62 + 56 + 49 + 40 + 7 + 80 + 23 + 25 +
63) = .15 (999) = 149.9 LB./BOOSTER

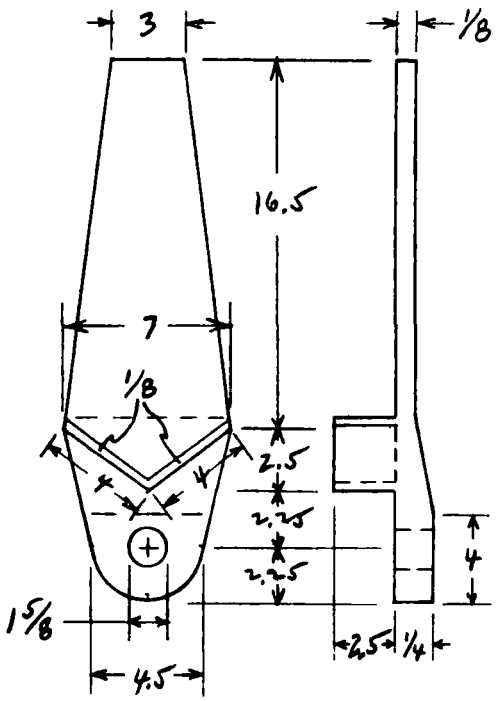
TOTAL JET FLAP MAIN STRUCTURE WT. = 1148.9 LB./
BOOSTER

JET FLAP (CONT'D.)

HINGE FITTINGS

HINGE FITTING (2 PER FLAP)

WT. = 10 (2) [16.5 (3+7) .125/2 +
2.5 (4+4) .125 + 2.5 (6.4) .18 +
2.25 (5.1) .25 + π/8 (4.5)² .25 −
π/4 (1.625)² .25] .330 =
132. LB./BOOSTER.



HINGE PINS (2 PER FLAP)

1 5/8 IN. DIA. X 3 IN. LONG

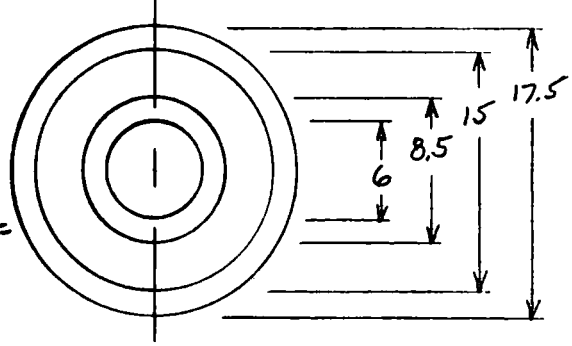
WT. = 10 (2) 3 (π/4) (1 5/8)² .303 = 38. LB./BOOSTER

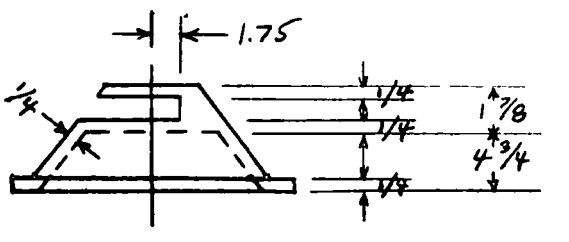
TOTAL HINGE FITTINGS WT. = 170. LB./BOOSTER

CONTROL FITTINGS

DRIVE FITTING (2/5 PER FLAP)

WT. = 10 (2/5) {π/4 (17.5)² 1/4 +
π/12 (6 5/8 − 1/4) [(15)² + (6)² +
6 (15)] − π/12 (4 3/4) [(15 − .35)² +
(8.5 − .35)² + 14.65 (8.15)] −
π/2 [(1.75)² + (3.625)²] 1 3/8} .330 =
166. LB./BOOSTER.

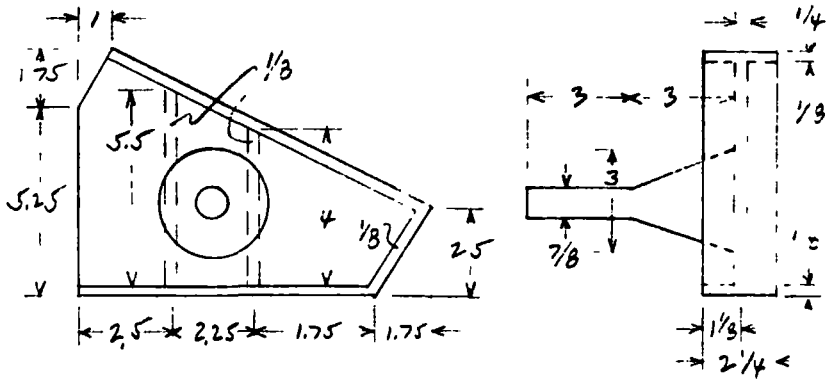




2.2-112

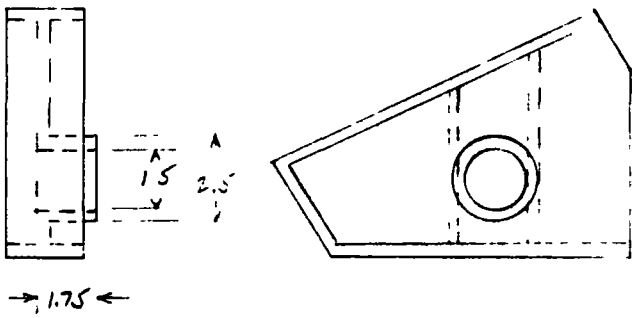
11. FLAP CONTROL FITTINGS (CON'D)

DRIVE PINS (4/5 PER FLAP)



WT. = 10 (4/5) {[1(5.25+1.75/2) + 7.25(7+2.5)/2 - 1.75(2.5/2)] 1/4 +
[(8.25 + 1.75 + 6.5)(2.25 - .25) + (5.5 + 4)1] 1/8 +
π/12 (3)[(3)² + (7/8)² + 3(7/8)] + π/4 (7/8)² 3 } .330 =
70. LB. / BOOSTER

DRIVE PIN FITTINGS (4/5 PER FLAP)



(SAME AS DRIVE PIN EXCEPT AS SHOWN)

WT. = 10 (4/5) [15.2 CU. IN. + π/4 (2.5)² (1.75 - .25) -
π/4 (1.5)² 1.75] .330 = 51. LB. / BOOSTER

TOTAL JET FLAP CONTROL FITTINGS WT. = 166 + 70 +
51 = 297. LB / BOOSTER

148599

ITEM BODY GROUP	WEIGHT-LB.	PAGE NO.
INTEGRAL TANKAGE	102,261	
FUEL TANK (LH_2)	[61,662]	2.3-10
FWD BULKHEAD	(2,631)	
SHELL	1,343	
RESTRAINING RING	970	
WELD LAND	229	
ACCESS DOOR	89	
SIDEWALL	(51,053)	
ISOGRID SIDEWALL	47,757	
WELD LAND	3,050	
WING ATTACH BEEF-UP	44	
ORBITER ATTACH BEEF-UP	202	
AFT BULKHEAD	(3,223)	
SHELL	1,383	
RESTRAINING RING	1,096	
WELD LAND	218	
SUMP	526	
CONTINGENCY - 5%	(2,845)	
BAFFLES	(1,910)	
OXIDIZER TANK (LOX)	[19,769]	2.3-39
FWD BULKHEAD	(300)	
SHELL	124	
RESTRAINING RING	105	
WELD LAND	30	
ACCESS DOOR	41	
SIDEWALL	(9,992)	
ISOGRID SIDEWALL	9,191	
WELD LAND	801	

BODY GROUP (CONT'D)

	WEIGHT-LB.	PAGE NO.
AFT BULKHEAD	(4,107)	
SHELL	2,003	
RESTRAINING RING	1,512	
WELD LAND	257	
SUMP	335	
CONTINGENCY - 5%	(720)	
BAFFLES	(4,650)	
BETWEEN TANKS (INTERTANK)	[16,717]	2.3-60
FWD FRAME	(2,486)	
VERTICAL DIAGONALS	895	
CANTED DIAGONALS	848	
INNER CAP	577	
DIAGONAL ENDS - OUTER	113	
DIAGONAL ENDS - INNER	53	
AFT FRAME	(1,423)	
VERTICAL DIAGONALS	445	
CANTED DIAGONALS	439	
INNER CAP	373	
DIAGONAL ENDS - OUTER	113	
DIAGONAL ENDS - INNER	53	
BOLTED JOINTS	(1,582)	
CIRCUMFERENTIAL JOINTS	1,392	
LONGITUDINAL JOINTS	190	
SIDEWALL	(10,626)	
ISOGRID SIDEWALL	10,240	
ORBITER ATTACH BEEF-UP	386	
CONTINGENCY - 4%	(600)	
INSULATION - FUEL TANK	[4,113]	2.3-84
FUEL TANK INTERNAL INSULATION	(4,113)	
LINER	971	
FOAM	1,785	
BOND	1,357	

BODY GROUP (CONT'D)

	WEIGHT-LB.	PAGE NO.
BASIC STRUCTURE	38,764	
NOSE SECTION SHELL	[967]	2.3-85
THRUST STRUCTURE	[37,797]	2.3-87 & 88
SIDEWALL - STA 3553 - STA 3600	(2,148)	
ISOGRID SIDEWALL	1,733	
JOINT PENALTY - CIRCUMFERENTIAL	399	
JOINT PENALTY - LONGITUDINAL	16	
SIDEWALL - STA 3604 - STA 3710	(4,244)	
ISOGRID SIDEWALL	3,820	
JOINT PENALTY - CIRCUMFERENTIAL	382	
JOINT PENALTY - LONGITUDINAL	42	
SIDEWALL - STA 3714 - STA 3788	(2,891)	
ISOGRID SIDEWALL	2,596	
JOINT PENALTY - CIRCUMFERENTIAL	266	
JOINT PENALTY - LONGITUDINAL	29	
FRAME - STA 3600	(2,686)	
CAP	1,816	
WEB	774	
BRACES	96	
FRAME - STA 3710	(3,722)	
CAP	2,410	
WEB	1,250	
BRACES	62	
FRAME - STA 3792	(4,560)	
CAP	2,957	
WEB	1,538	
BRACES	65	
INBOARD BEAMS AND WEB	(8,660)	
BEAMS	3,643)	
CENTER WEB	3,040	
VERTICAL - OUTBOARD WEB	1,977	

BODY GROUP (CONT'D)

	WEIGHT-LB.	PAGE NO.
LAUNCH LOAD FITTINGS	(3,000)	
UPPER LAUNCH FITTINGS	1,580	
LOWER LAUNCH FITTINGS	692	
LOAD DISTRIBUTION LONGERONS	728	
STIFFENERS AND FITTINGS	(2,544)	
ACTUATOR LOAD STIFFENERS	613	
ENGINE LOAD STIFFENERS	922	
ENGINE MOUNTING FITTINGS	835	
ACTUATOR ATTACH FITTINGS	149	
HEAT SHIELD ATTACH FITTINGS	25	
BOAT TAIL	(4,358)	
SUPPORT TRUSS	851	
EXTERIOR ISOGRID PANELS	2,999	
TRUSS SUPPORT STRUTS	160	
TRUSS SUPPORT BEAMS	248	
BASE HEAT STAND-OFF FITTINGS	100	
REDESIGN OF AFT SKIRT & THRUST STRUC.	(-1,016)	
SECONDARY STRUCTURE	7,574	
CREW COMPARTMENT	[1,920]	2.3-159
FLOOR	(429)	
UPPER PANEL (ISOGRID)	167	
LOWER PANEL (ISOGRID)	102	
CORE (TRUSS)	104	
SIDEWALL ATTACH ANGLES	35	
MISCELLANEOUS & ATTACH PARTS	21	
AFT PRESSURE BULKHEAD	(400)	
FWD PANEL (ISOGRID)	130	
AFT PANEL (ISOGRID)	100	
CORE (TRUSS)	73	
SIDEWALL & FLOOR ATTACH ANGLES	31	
ACCESS DOOR	47	
MISCELLANEOUS & ATTACH PARTS	19	

BODY GROUP (CONT'D)

	WEIGHT-LB	PAGE NO.
FWD PRESSURE BULKHEAD	(85)	
ISOGRID PANEL	68	
SIDEWALL & FLOOR ATTACH ANGLES	13	
MISCELLANEOUS & ATTACH PARTS	4	
LONGITUDINAL PRESSURE PANELS	(78)	
STIFFENED PANEL - LEFT HALF	19	
STIFFENED PANEL - RIGHT HALF	34	
SIDEWALL FORMERS	9	
ATTACH ANGLES (STA 1069 & 1169)	2	
SIDEWALL & FLOOR ATTACH ANGLES	10	
MISCELLANEOUS & ATTACH PARTS	4	
CREW DOOR & JAMB	(176)	
COCKPIT ENCLOSURE	(752)	
WINDSHIELD INSTALLATION	450	
WINDSHIELD THERMAL PROTECTION	302	
DOORS - LANDING GEAR	[1,302]	2.3-170
NOSE GEAR DOOR	(355)	
DOOR	273	
JAMB	72	
MISCELLANEOUS & ATTACH PARTS	10	
MAIN GEAR DOORS	(947)	
DOORS & JAMB	784	
OPERATING MECHANISM	92	
ACTUATION	46	
LOCK MECHANISM	25	
GEAR/WING PROVISIONS	[4,352]	2.3-172
NOSE GEAR WELL	(875)	
SIDE PANELS	537	
COVER	192	
TRUSS	3	
WEB IN FRAMES	61	
MISCELLANEOUS & ATTACH PARTS	56	
CONTINGENCY - 3%	26	

BODY GROUP (CONT'D)

	WEIGHT-LB	PAGE NO.
MAIN GEAR PICKUP	(5,084)	
TRUSS - UPPER HALF - STA 3635	761	
TRUSS - LOWER HALF - STA 3635	548	
CENTER TRUSS - STA 3660	438	
LOAD PICKUP FITTING - STA 3660	80	
TRUSS - UPPER HALF - STA 3685	798	
TRUSS - LOWER HALF - STA 3685	636	
INTERCOSTALS	428	
TRUSS TORQUE BOX PANELS	896	
PANEL SUPPORT ANGLES	37	
MISCELLANEOUS & ATTACH PARTS	462	
MAIN GEAR ENCLOSURE	(647)	
ENCLOSURE PANELS	310	
PANEL SUPPORT ANGLES	157	
PANEL STIFFENERS	107	
DOOR PENALTY	14	
MISCELLANEOUS & ATTACH PARTS	59	
REDESIGN OF MAIN GEAR PICKUP	(-3,377)	
CANARD ATTACH	(578)	
TRUSS - STA 1953	115	
TRUSS - STA 2093	289	
TRUSS BRACES	103	
SHEAR PANEL	54	
MISCELLANEOUS ATTACH PARTS	17	
WIND LEADING EDGE ATTACH	(545)	
"4" FINGER SECTIONS	140	
"2" FINGER SECTIONS	74	
STRUTS	72	
FITTING - INNER HALF	30	
FITTING - OUTER HALF	70	
ATTACH PARTS	40	
SPECIAL FINGER ATTACH PLUGS	99	
MISCELLANEOUS	20	

WEIGHT SUBSTANTIATION - BODY GROUP

THE WEIGHT SUBSTANTIATION FOR THE BOOSTER BODY GROUP CONSISTS PRIMARILY OF DETAIL WEIGHT CALCULATIONS BASED ON THE DESIGN SHOWN ON THE REFERENCED DRAWINGS. UNLESS OTHERWISE INDICATED, THE DESIGN HAS BEEN VERIFIED BY A DETAIL STRESS ANALYSIS. ALL STRESS CALCULATIONS INCLUDING LOADS AND ASSUMPTIONS ARE PRESENTED IN MDAC MEMO NUMBER SSPI-E450-576, AIRFRAME, PART II BOOSTER AIRFRAME, SECTION 4

THE BOOSTER BODY GROUP CONSISTS OF THE FOLLOWING MAJOR ASSEMBLIES OR SUB-ASSEMBLIES:

(1) FUEL TANK (LH_2)
   DRAWING NO 256-20-0013, LAYOUT - LH_2 TANK ASSY., SHEETS 1 & 2
   MATERIAL: ALUMINUM 2219-T87
(2) OXIDIZER TANK (LOX)
   DRAWING NO. 256-20-0013, LAYOUT - LOX TANK ASSY., SHEETS 1 & 2
   MATERIAL: ALUMINUM 2219-T87
(3) INTERTANK
   DRAWING NO. 256-20-0017, INTERTANK STRUCTURE, SHEETS 1, 2, & 3
   MATERIAL:
      ISOGRID SIDEWALL - ALUMINUM 2219-T87
      INTERNAL FRAMES - ALUMINUM 7075-T7351
(4) LH_2 TANK INTERNAL INSULATION
(5) NOSE SHELL
   DRAWING NO. 256-20-0015, NOSE SECTION CONFIG 20, SHEET 2
   MATERIAL: ALUMINUM 2219-T87

⑥ AFT SHIRT & THRUST STRUCTURE
DRAWING NO 256-20-0032, AFT BODY STRUCTURE ASSY CONFIG 20, SHEETS 1, 2, 4 & 7
MATERIAL:
BASIC STRUCTURE - ALUMINUM 2219-T87 & 7075-T7351
LAUNCH FITTINGS - TITANIUM

⑦ CREW COMPARTMENT
DRAWING NO. 256-20-0015, NOSE SECTION BOOSTER CONFIG 20, SHEETS 1 & 3
MATERIAL: ALUMINUM 7075-T7351

⑧ & ⑨ LANDING GEAR DOORS
DRAWING NO 256-20-0027-REV A AND
PROFILE, MODEL 256-20B LOFTER
MATERIAL: ALUMINUM

⑩ NOSE GEAR WELL
DRAWING NO 256-20-0017, INTERTANK STRUCTURE, SHEET 5
MATERIAL: ALUMINUM 7075-T7351

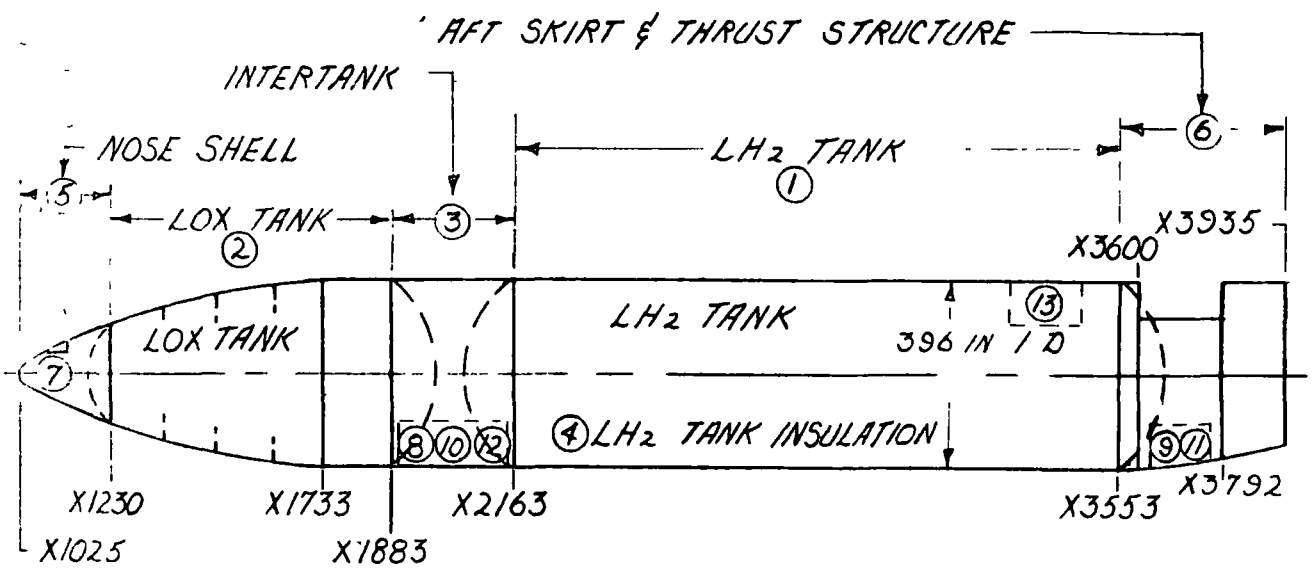
⑪ MAIN GEAR PICK-UP
DRAWING NO. 256-20-0002, AFT BODY STRUCTURE CONFIG 20, SHEET 5
MATERIAL: ALUMINUM 7075-T7351

⑫ CANARD ATTACH
DRAWING NO 256-20-0017, INTERTANK STRUCTURE, SHEET 1
MATERIAL: ALUMINUM 7075-T7351

⑬ WING LEADING EDGE ATTACH
DRAWING NO. 256-20-007, WING LEADING EDGE ATTACHMENT
MATERIAL: ALUMINUM 7075-T7351

THE GENERAL ARRANGEMENT OF THESE ITEMS IS SHOWN ON THE SKETCH ON THE FOLLOWING PAGE.

BODY GROUP



(7) CREW COMPARTMENT
(8) NOSE GEAR DOOR
(9) MAIN GEAR DOORS
(10) NOSE GEAR WELL
(11) MAIN GEAR PICK-UP
(12) CANARD ATTACH
(13) WING LEADING EDGE ATTACH

3. BODY GROUP						148599
INTEGRAL TANKAGE						102261
(1) FUEL TANK					61662	
(2) OXIDIZER TANK					19769	
(3) BETWEEN TANKS (INTERTANK)					16717	
(4) INSULATION					4113	
BASIC STRUCTURE	FWD. (967)	CTR, (____)	AFT, (____)	SKIRT (37797)		38764
(5) SIDEWALLS (NOSE SHELL)	967					
BULKHEADS						
PARTITIONS						
(6) THRUST STRUCTURE (MAIN ASCENT ENGINE)				37797		
SECONDARY STRUCTURE						7574
(7) CREW COMPARTMENT					1920	
EQUIPMENT COMPARTMENTS						
RADOME/ANTENNAS						
SPEED BRAKES						
ENGINE HEAT PROTECTION						
INTERSTAGE (INCL. MECH. ____ LBS)						
(9)(11) DOORS (LANDING GEAR)					1302	
GEAR/WING PROVISIONS (10)(11)(12)(13)					4352	

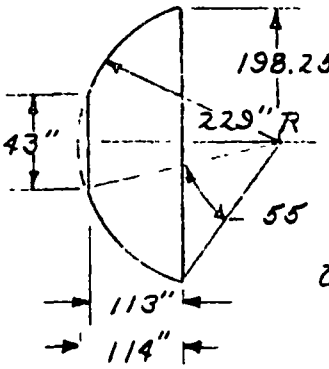
WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
① FUEL TANK (LH_2)		[61662]
FWD BULKHEAD		(2631)
SHELL	11	1343
RESTRAINING RING	11	970
WELD LAND	12	229
ACCESS DOOR	12	89
SIDEWALL		(51053)
ISOGRID SIDEWALL	13	47757
WELD LAND	14	3053
WING ATTACH BEEF-UP	16 TO 20	44
ORBITER ATTACH BEEF-UP	21 TO 32	202
AFT BULKHEAD		(3223)
SHELL	33	1363
RESTRAINING RING	33	1096
WELD LAND	34	218
SUMP	35 & 36	526
CONTINGENCY 5 %		(2845)
BAFFLES	37	(1910)

FWD BULKHEAD - LH_2 TANK

SHELL

PRESSURE = 30.0 PSI LIMIT
= 1.5(30.0) = 45.0 PSI ULTIMATE



σ_{tu} = 63,000 (1.07)* = 67,400 PSI

* GUARANTEED TYPICAL FACTOR

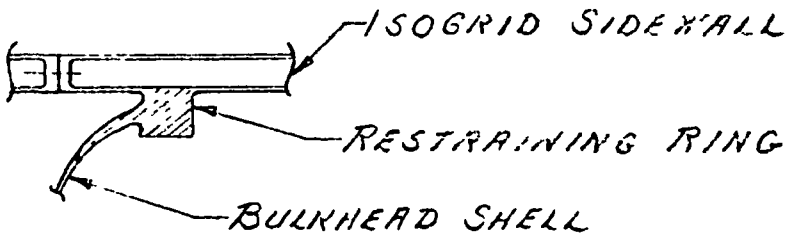
$$t = \frac{PR}{2\sigma} = \frac{45(229)}{2(67,400)} = 0.076 \text{ MIN}$$

= 0.081 Nom ± 0.005

AREA = $2\pi RH = 2\pi(229)113 = 162,500$ IN²

SHELL WEIGHT = $A\ell\rho = 162,500(0.081)0.102 =$ **1,343 LB**

RESTRAINING RING



TIPICAL JOINT

R_o = 198.25
ρ = 0.102 LB/IN³
P = 30 PSI
F.S. = 1.5
σ_{tu} = 67,400 PSI *
H = 114 IN

* TEST DATA FROM THE THOR-DELTA PROGRAM INDICATE THAT BUCKLING ALLOWABLES SHOULD BE CLOSE TO THE TENSILE ULTIMATE.

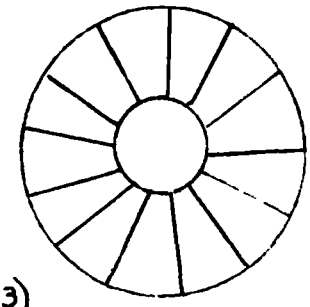
$$\text{RING WT} = \frac{\pi R_o^3 \rho P}{\sigma}\left[\frac{1-\left(\frac{H}{R_o}\right)^2}{2\left(\frac{H}{R_o}\right)}\right] \text{F.S.} =$$

970 LBS

FWD BULKHEAD - LH_2 TANK (CONT.)

WELD LAND PENALTY

TYPICAL WELD



13 SEGMENTS

$t_{WELD} = 2.8\ t_{SKIN}$

$$\text{WELD LENGTH} = 13\pi(229)\left(\frac{110}{360}\right) + 2\pi\left(198.25 + \frac{43}{4}\right)$$

$$= 4{,}110 \text{ IN}$$

$$\text{WELD WEIGHT} = 3.75\left(2.8\ t_{SKIN} - t_{SKIN}\right)L\,I^2$$

$$= 3.75\left[(1.8)(0.081)\right](4{,}110)\,0.102 = \boxed{229 \text{ LBS}}$$

TANK - ACCESS PROVISIONS

THE WEIGHT OF THE TANK ACCESS DOOR IN THE FORWARD BULKHEAD IS BASED ON THE 43 INCH DIAMETER DOOR IN THE S-IVB LH_2 TANK FORWARD BULKHEAD.

S-IVB DATA

BULKHEAD SKIN THICKNESS = 0.060 INCH

WEIGHT:

DOOR =	37 LB
ATTACH FLANGE =	29 LB
TOTAL	66 LB

SHUTTLE DOOR WEIGHT

BULKHEAD SKIN THICKNESS = 0.081 INCH

$$\text{WEIGHT} = \frac{0.081}{0.060}(66) = \boxed{89 \text{ LB}}$$

LH_2 TANK SIDEWALL

SPAN	r IN	R IN	H IN	ρ LB/IN³	$\bar{t}_{NOM}$ ** ±0.005" t_1	t_2	WEIGHT LB	C.G. STA
STA 2163 - 2303	198.6	198.6	140	0.102	.247	.247	4,399	2233
STA 2303 - 2443	198.6	198.6			.232	.232	4,132	2373
STA 2443 - 2583	198.6	198.6			.229	.229	4,079	2513
STA 2583 - 2723	198.6	198.6			.244	.244	4,346	2653
STA 2723 - 2863	198.6	198.6			.257	.257	4,577	2793
STA 2863 - 3003	198.6	198.6			.275	.275	4,898	2933
STA 3003 - 3143	198.6	198.6			.278	.278	4,951	3073
STA 3143 - 3283	198.6	198.6			.259	.259	4,613	3213
STA 3283 - 3423	198.6	198.6	140		.243	.243	4,328	3353
STA 3423 - 3553	198.6	198.6	130	0.102	.242	.242	4,310	3488
							44,633	2871
SIDEWALL NODAL PENALTY 7%							3,124	2871
TOTAL SIDEWALL (LESS WELD LAND PENALTY)							47,757 *	2871

* THE LH_2 TANK IS CRITICAL FOR FLIGHT LOADS SO THERE IS NO ADDITIONAL WEIGHT PENALTY FOR PROOF TEST SIMULATED PRESSURE GRADIENT.

** SEE PAGE 2.3-15 FOR $\bar{t}$ CALCULATIONS

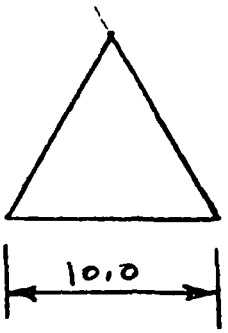
WELD LAND PENALTY - LH2 TANK SIDEWALL

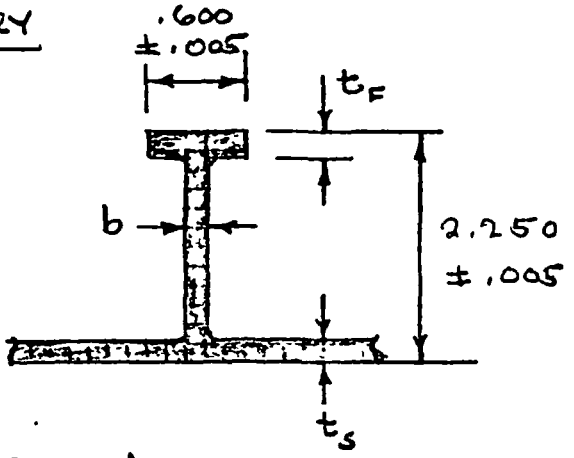
THE WELD LAND PENALTY IS BASED ON THE WELD LAND BEING 6.25 INCHES WIDE AND 28 TIMES THE ISOGRID SKIN THICKNESS THICK. EACH SECTION HAS ONE CIRCUMFERENTIAL WELD AND THREE LONGITUDINAL WELDS.

	WELD LENGTH	t_{SKIN} Nom *	WEIGHT LB.	C.G. STA.
STA 2163-2303	$L = \pi(396.5) + 3(140) = 1,665''$	$WT = 6.25(18)(.159)(1,665)(.102) =$	304	2233
STA 2303-2443		1,910 59(.154)	294	2373
STA 2443-2583		(153)	292	2513
STA 2583-2723		(159)	302	2653
STA 2723-2863		(162)	310	2793
STA 2863-3003		(167)	319	2933
STA 3003-3143		(168)	321	3073
STA 3143-3283		(163)	311	3213
STA 3283-3423	1,665"	(158)	302	3353
STA 3423-3553	$L = \pi(396.5) + 3(130) = 1,635''$	$WT = 6.25(18)(.157)(1,635)(.102) =$	295	3488
	WELD LAND PENALTY		3,050	2866

* SEE PAGE 2.3-15 FOR [illegible]

LH_2 TANK NOMINAL GEOMETRY





$E_c = 10.8 \times 10^6$ psi. $R_{eff} = 198.6$ in.

STATION IN.	N_{cr} LB./IN.	t_s ±.005 IN.	b ±.005 IN.	t_F ±.005 IN.	$\bar{t}$ * IN.	LENGTH OF SEG.
2163 - 2303	8850	.159	.074	.200	.247	140
2303 - 2443	7980	.154	.071	.150	.232	
2443 - 2583	7670	.153	.071	.140	.229	
2583 - 2723	8670	.158	.073	.190	.244	
2723 - 2863	9500	.162	.074	.237	.257	
2863 - 3003	10540	.167	.077	.300	.275	
3003 - 3143	10700	.168	.077	.311	.278	
3143 - 3283	9530	.163	.074	.238	.259	
3283 - 3423	8530	.158	.073	.183	.243	
3423 - 3553	8500	.157	.073	.182	.242	130

* LATEST MATERIAL REQUIREMENTS – SUPERCEDES INFORMATION ON DWG # 256-20-0013

ALUMINUM SCREEN FOR WING SKIN

LOWER FITTING REED-UP

THE LH2 TANK SIDEWALL IS STIFFENED FOR 60" IN THE LONGITUDINAL DIRECTION & 113" IN THE CIRCUMFERENTIAL DIRECTION (TAPERS 57", BOTH DIRECTIONS FROM THE CENTER OF ATTACH LOCATION)

CURRENT $\bar{E}$ @ STA 3325 IS 0.241"

ADDITIONAL MATERIAL NEEDED

STEP 1

AREA = 60(4.33) = 260 IN^2

$\Delta\bar{E}$ = (.2157/.1615)(.241) − 241 = .081"

VOLUME = 260(.081) = 21 IN^3

STEP 2

AREA = 60(8.66) = 520 IN^2

$\Delta\bar{E}$ = (.2157/.1615)(.241) − 241 = .081

VOLUME = 520(.061) = 32 IN^3

STEP 3

AREA = 60(3.66) = 220 IN^2

$\Delta\bar{E}$ = (.1765/.1615)(.241) − 241 = .036"

VOLUME = 520(.036) = 19 IN^3

STEP 4

AREA = 60(3.66) = 220 IN^2

$\Delta\bar{E}$ = (.1765/.1615)(.241) − .241 = .022"

VOLUME = 520(.022) = 12 IN^3

STEP 5

AREA = 60(3.66) = 220 IN^2

$\Delta\bar{E}$ = (.1765/.1615)(.241) − 241 = .014"

VOLUME = 520(.014) = 8 IN^3

STEP 6

AREA = 60(3.66) = 220 IN^2

$\Delta\bar{E}$ = (.1665/.1615)(.241) − .241 = .003"

VOLUME = 520(.003) = 4 IN^3

STEP 7

AREA = (1.1766) = 520

$\Delta\bar{E}$ = (1631/1615)(.241) − 241 = .003"

VOLUME = 520(.003) = 2 IN^3

HALF C = VOLUME/FITTING = 98 IN^3

TOTAL VOLUME FOR BOTH LOWER FITTINGS = 2(2)(98) = 392 IN^3

UPPER FITTING BEEF-UP WING LEADING EDGE ATTACH

THE LH_2 TANK SIDEWALL IS STIFFENED FOR 20" IN THE LONGITUDINAL DIRECTION & 43" IN THE CIRCUMFERENTIAL DIRECTION (TAPERS 21.5" IN BOTH DIRECTIONS FROM THE CENTER OF ATTACH LOCATION)

CURRENT $\bar{z}$ @ STA 3325 IS 0.241"

ADDITIONAL MATERIAL VOLUME

STEP 1

AREA = 20(4.33) = 87 IN^2
$\Delta\bar{z}$ = (.2079/.1615)(.241) − .241 = .069"
VOLUME = 87(.069) = 6 IN^3

STEP 2

AREA = 20(9.66) = 174 IN^2
$\Delta\bar{z}$ = (.1739/.1615)(.241) − .241 = .018"
VOLUME = 174(.018) = 3 IN^3

STEP 3

AREA = 20(9.66) = 174 IN^2
$\Delta\bar{z}$ = (.1622/.1615)(.241) − .241 = .002"
VOLUME = 174(.002) = 1 IN^3

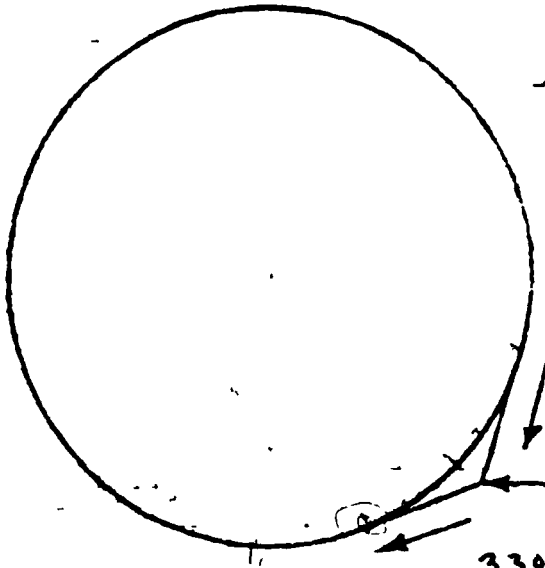
HALF OF VOLUME/FITTING 10 IN^3

TOTAL VOLUME FOR BOTH UPPER FITTINGS = 2(2)(10) = 40 IN^3

TOTAL LH_2 TANK WT PENALTY FOR WING ATTACH:

WT = (392 + 40)(.102) = 44 LB

WING LEADING EDGE ATTACH



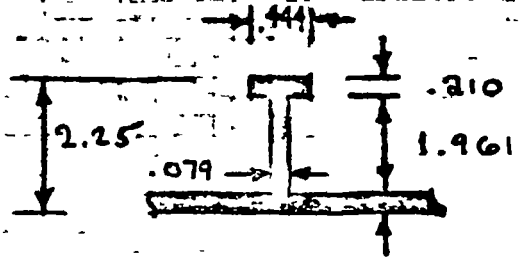
$p = \frac{121}{10} = 12.1$ lb/in (ULT.)

$F = \pm 250$ lb (ULT.)

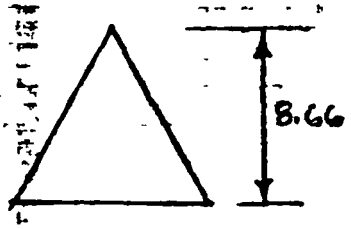
$p_o = \frac{330}{30} = 11.0$ lb/in. (ULT.)

STA. 3325

AT STA. 3325 THE COMPRESSIVE ULT. LOAD/IN OF 7600 LB./IN. REQUIRES THE FOLLOWING STIFFENING



RIB SECT.



GRID

FOIL 22.9 -87 MAT.

$F_{cu} = 68.5$ ksi.

THE COMBINED STRESSES ARE GIVEN BY:

$$F_{cu} = \frac{kE}{t'(1+\alpha)} \text{ (INTERNAL PRESS.)} + \frac{k_2 p_o}{6rt(1+\alpha)} \text{ (SHEAR LAG)}$$

k_1 IS OBTAINED TABLE $\frac{cJ_y}{p_o}$ AS A FUNCTION OF $\frac{y}{b}$.

WHERE p_o IS THE LINE LOAD/IN. AND b IS THE HALF LOADED WIDTH.

[illegible] WING [illegible] BEEF-UP

FOR THE 11.0 k/in. LOAD, $b = \frac{30.0}{2} = 15.0$ in.,
THE REQ. EFFECTIVE THICKNESS IS:

$$t(1+\alpha)_{min.} = \frac{pR}{F_{tu}} + \frac{k p_o}{6\pi F_{tu}} \quad ; \quad \frac{pR}{F_{tu}} = \frac{48.5 \times 198.6}{68.5} \times 10^{-3} = .1407$$

$$\frac{p_o}{6\pi F_{tu}} = \frac{11.0}{6\pi \times 68.5} = .00853 \text{ in.}$$

POCKET	y	$\frac{y}{b}$	$k = \frac{c\sigma_y}{p_o}$	$\frac{k p_o}{6\pi F_{tu}}$	$\frac{pR}{F_{tu}}$	$t(1+\alpha)_{min.}$
1	4.33	.289	8.80	.0750	.1407	.2157
2	12.99	.866	7.20	.0614	↓	.2021
3	21.65	1.445	5.27	.0449	↓	.1856
4	30.31	2.02	4.20	.0358	↓	.1765
5	38.97	2.60	3.50	.0298	↓	.1705
6	47.63	3.17	3.02	.0258	↓	.1665
7	56.29	3.75	2.63	.0224	↓	.1631
8	64.95	4.33	2.30	.0196	↓	.1603

$t(1+\alpha)_{min.}$ IN THE UNREINFORCED SECTION IS 0.1615 in.

UPPER WING ATTACH LEEF-UP

FOR THE 12.1 k/in. LOAD, $b = \frac{10.0}{2} = 5.00$ in.

$$\frac{p_o}{6\pi F_{tu}} = \frac{12.1}{6\pi \times 68.5} = .00935 \text{ in.}$$

POCKET	y	$\frac{y}{b}$	$k = \frac{c\sigma_y}{p_o}$	$\frac{k p_o}{6\pi F_{tu}}$	$\frac{pR}{F_{tu}}$	$t(1+\alpha)_{min}$
1	4.33	.866	7.20	.0672	.1407	.2079
2	12.99	2.60	3.50	.0327	↓	.1734
3	21.65	4.33	2.30	.0215	↓	.1622
4	30.31	6.06	1.63	.0152	↓	.1559

$t(1+\alpha)_{min}$ IN THE UNREINFORCED SECTION IS 0.1615 in.

LH_2 TANK AT AFT ORBITER ATTACHMENT

SUMMARY

ATTACHMENT REACTING P_1 (REF. p. 2)

INCREASE RIB VOLUME LOCALLY A TOTAL AMOUNT $V = 342\ IN^3$ (REF. p. 11)

ATTACHMENT REACTING P_2 (REF p. 2)

INCREASE RIB VOLUME LOCALLY A TOTAL AMOUNT $V = 650\ IN^3$ (REF. p 10)

THE ABOVE ADDED MATERIAL INSURES THAT THE LOAD CAN BE REACTED INTO THE SKIN-ISOGRID STRUCTURE.

PRELIMINARY CALCULATIONS SHOW THAT THE SKIN-ISOGRID STRUCTURE CAN THEN, AT LEAST INITIALLY, ACCEPT THE LOADS WITHOUT MORE BEEF UP.

FURTHER CALCULATIONS ARE NEEDED TO CHECK MORE OVERALL SHELL STRESSES IN VICINITY OF ATTACHMENT, AND THESE CALCULATIONS ARE UNDERWAY.

UPPER BEEF-UP - WT = 342(.102) = 35 LB
LOWER BEEF-UP - WT = 650(.102) = 66 LB
TOTAL 101 LB/SIDE

TOTAL FOR BOTH SIDES 202 LB

LH_2 TANK AT AFT ORBITER ATTACHMENT

THE AFT ORBITER ATTACHMENT LOADS ARE APPLIED TO THE LH_2 TANK TANGENTIALLY. LOCALLY IN THE ATTACHMENT AREA, THE LH_2 TANK MUST BE STRENGTHED TO TAKE THE TANGENTIAL LOADS.

THIS ANALYSIS CONCERNS A PRELIMINARY SIZING OF THE LOCALLY ADDED STRUCTURE.

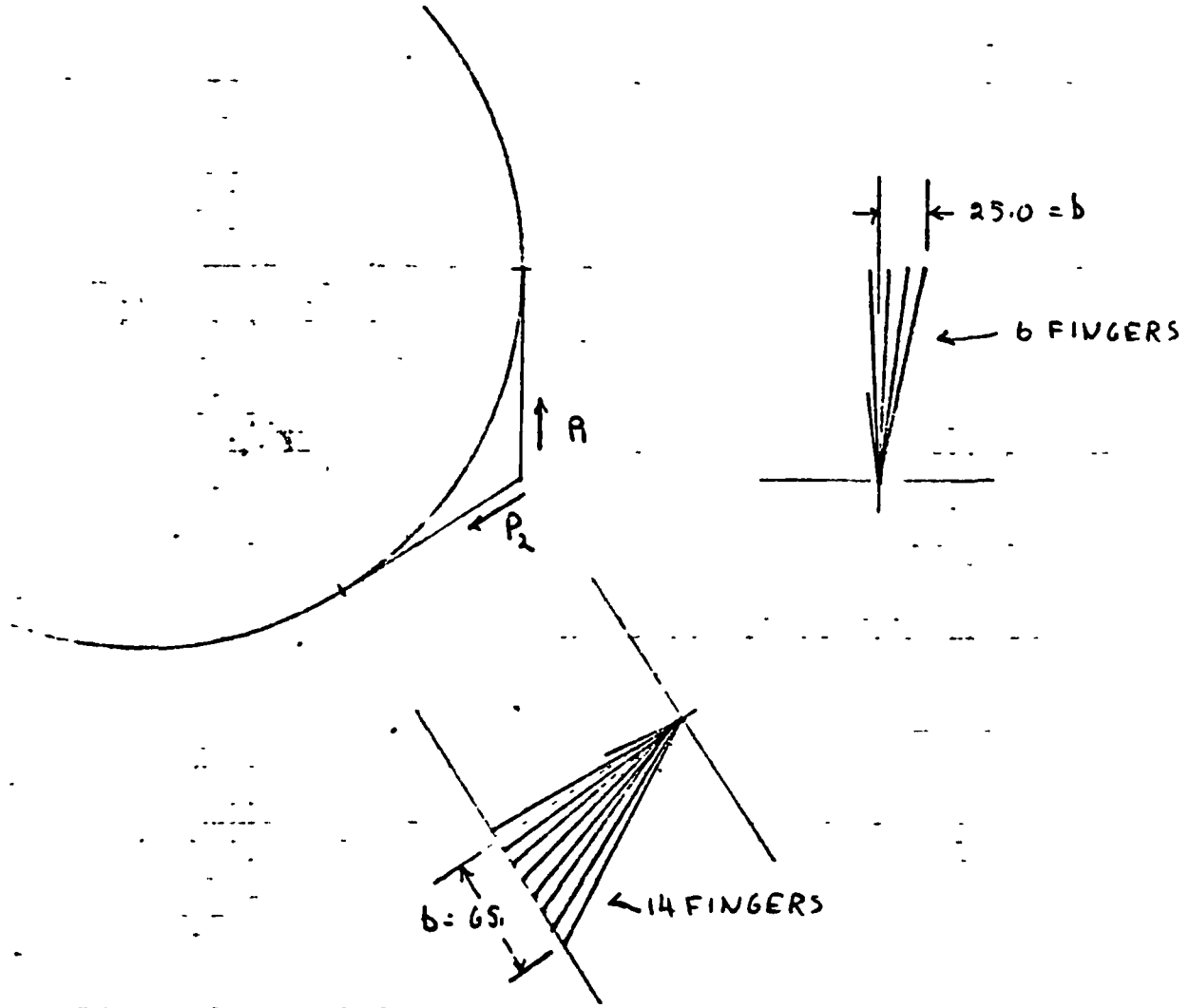
SKIN - RIB (ISOGRID) LH_2 TANK MATERIAL IS 2219-T 87

MATERIAL PROPERTIES MILHDBK-5, -P- 3.2.25.0(b)

F_u = 64,000 lb/in²

F_y = 51,000 lb/in²

GEOMETRY OF ATTACHMENT
(DWG 256-20-0006)



(ULTIMATE)
MAXIMUM VALUES FOR P_1 AND P_2

$P_1 = 305{,}000$ lb (REF. AFT ORITER ATTACHMENT ANALYSIS, p. 5)
$P_2 = 608000$ lb

FORCE PER INCH ACTING ON TANK

$$p = \frac{P}{2b} \quad \text{(REF. p. 2)}$$

THEN

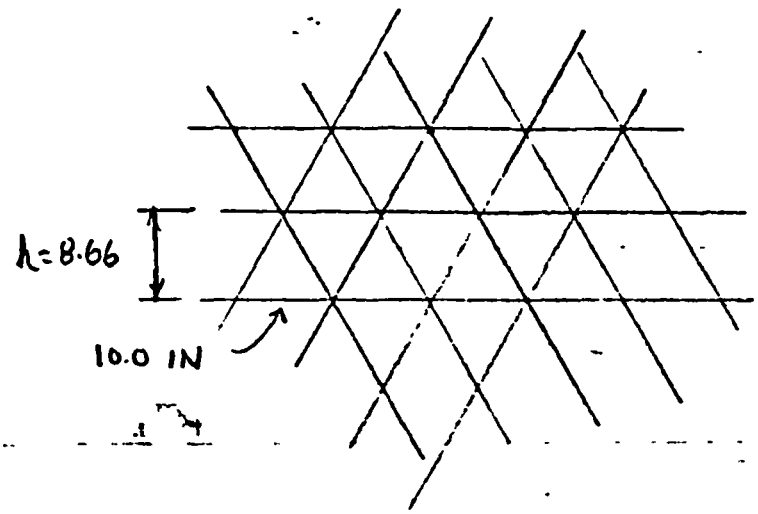
$$p_1 = \frac{305{,}000}{(2)(25)}$$

$$p_1 = 6100 \text{ lb/IN}$$

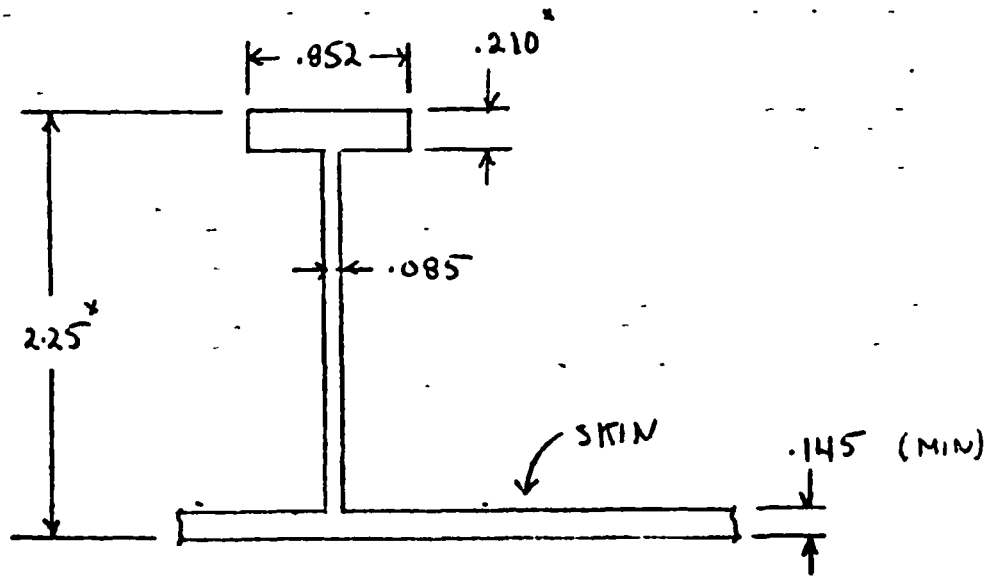
$$p_2 = \frac{609{,}000}{(2)(65.0)}$$

$$p_2 = 4680 \text{ lb/IN}$$

THE LH_2 TANK IS A SKIN-ISOGRID CONSTRUCTION. AT THE AFT ORBITER ATTACH, STA 2807, THIS CONSTRUCTION IS SHOWN BELOW.



RIB (TYPICAL) SKIN



REF. R.B MEYER

* THESE DIMENSIONS ARE FIXED

AN ISOGRID-SKIN CONSTRUCTION CAN BE APPROXIMATED AS A PLATE OR SHELL WITH AN EFFECTIVE THICKNESS AND YOUNG MODULUS. THE STANDARD PLATE OR SHELL FORMULAS THEN CAN BE APPLIED.

THE ISO GRID RIBS WILL BE STRENGTHED LOCALLY NEAR THE ATTACH POINTS, FOR APPROXIMATELY TWO GRID LENGTHS FROM THE ATTACHMENT POINTS. IT WILL BE ASSUMED THAT THE ISO GRID, FOR COMPUTING STRESSES ACTS LIKE A PLATE STARTING IMMEDIATELY AFT OF THE BUILT UP GRIDS.

THE RESULTING STRESS IN THE ISO GRID WILL BE COMPUTED FOR AN EFFECTIVE THICKNESS ASSUMING AN AVERAGE LINE LOAD. HALF THE LINE LOAD WILL CAUSE A COMPRESSION STRESS, AND HALF A TENSION STRESS.

THE LINE LOAD CORRESPONDING TO P_2 (REF p 2) IS

$$p_2 = 4680 \text{ lb/in} \quad \text{(ULTIMATE)}$$

AND CORRESPONDING TO P_1 (REF p 2) IS

$$p_1 = 6100 \text{ lb/in} \quad \text{(ULTIMATE)}$$

THE EFFECTIVE THICKNESS FOR A SKIN-ISO GRID IS

$$t_e = t(1+\alpha)$$ (REF CONSTITUTIVE EQUATIONS AND MEMBRANE SOLUTIONS FOR ISOTROPIC STIFFENED SHELLS, SM-49248, SEPT 1965, p 11)

WHERE $\alpha = \frac{A_2}{th}$.

A_2 = RIB AREA

h (REF p. 4)

t = SKIN THICKNESS

COMPUTING A_R AND α

$$A_R = (.852)(.210) + (1.895)(.085) = .340$$
$$(.179) \qquad (.161)$$

$$\alpha = \frac{A_R}{t h} = \frac{.340}{(.145)(8.66)} = .271$$

EFFECTIVE SKIN THICKNESS

$$t_e = t(1+\alpha) = .145(1+.271)$$

$$t_e = .184 \text{ IN}$$

STRESS DUE TO LINE LOAD p

$$\sigma = \frac{p}{2t_e}$$

FOR $p_1 = 6100$ lb/IN

$$\sigma_1 = \frac{6100}{(2)(.184)}$$

$\sigma_1 = 16{,}600$ lb/IN^2 (ULTIMATE)

FOR $p_2 = 4680$ lb/IN

$$\sigma_2 = \frac{4680}{(2)(.184)}$$

$\sigma_2 = 12{,}700$ lb/IN^2 (ULTIMATE)

THESE ARE SKIN STRESSES. RIB STRESSES ARE LOWER.

SKIN STRESSES FROM OTHER LOADING CONDITIONS

(REF R.R MEYER, STA. 2807 STRESS IN LH_2 TANK)

LIMIT

$\sigma = 32,300$ lb/in^2

ULTIMATE

$\sigma = 48,400$ lb/in^2

TOTAL STRESSES

σ_1 (ULT.) = 48 400 + 16 600 = 65 000 LB./IN^2.

σ_1 (LIMIT) = 32 300 + 16600/1.4 = 46 400 LB./IN^2.

COMPARING THESE STRESSES TO MATERIAL PROPERTIES

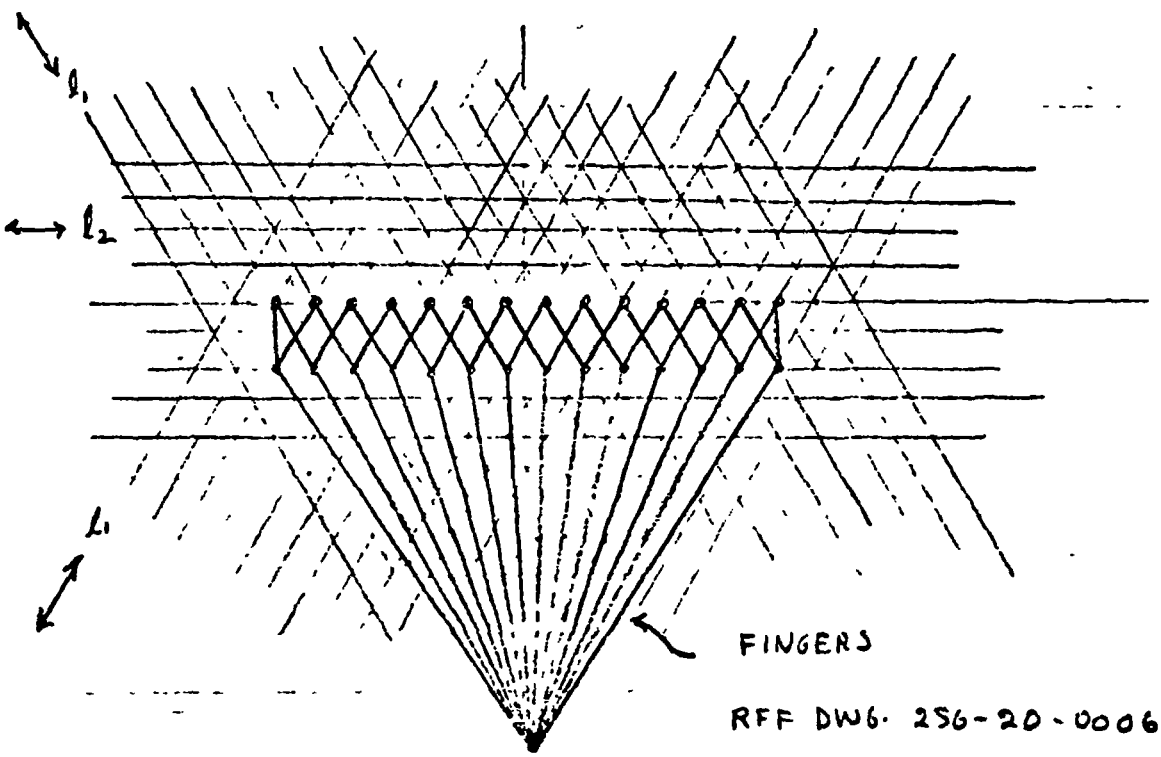
$F_u = 64,000$ lb/in^2 REF. p. 1

$F_y = 51,000$ lb/in^2

TOTAL STRESSES ON A LIMIT LOAD BASIS DO NOT EXCEED YIELD, AND ON AN ULTIMATE LOAD BASIS, SLIGHTLY EXCEED ULTIMATE.

FOR PRELIMINARY DESIGN PURPOSES, THIS ASPECT OF THE ISO GRID IS CONSIDERED ADEQUATE WITH NO ADDITIONAL MATERIAL ADDED TO SKIN-ISO GRID.

COMPUTING LOCAL BEEF UP OF RIBS



ISOGRID DIMENSIONS ARE SHOWN ON P. 4

COMPUTING LOCAL BEEF UP OF RIBS (CONT)

CONSIDERING P_2 RIBS (14 FINGERS) (REF p. 2)

$P_2 = 608{,}000$ lb (REF. p.3)

AVERAGE LOAD PER FINGER

$$P_A = \frac{608{,}000}{14}$$

$$P_A = 43{,}500 \text{ lb}$$

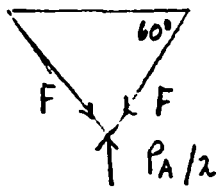
LOAD IN A BEEFED UP RIB

$$2F \sin 60^\circ = P_A/2$$

$$F = \frac{P}{4 \sin 60^\circ}$$

$$F = \frac{43{,}500}{(4) \sin 60^\circ}$$

$$F = 12{,}600 \text{ lb}$$



$P_A/2$ IS ASSUMED AS 1/2 P_A IS TAKEN BY EACH SIDE OF PLATE (EACH SIDE OF SHELL).

TAKE ALLOWABLE STRESS = $F_y = 51{,}000$ lb/in^2 (REF p 1)

COMPUTING ADDED AREA

$$\sigma = \frac{P}{A} \quad , \quad A = \frac{P}{\sigma}$$

$$A = \frac{12{,}600}{51{,}000}$$

$$A = .25 \text{ in}^2$$

CONSIDERING P_2 RIBS (CONT)

LENGTH OF RIBS FOR AREA INCREASE (REF. P 8)

$$l_1 = (2)(14)\{(6)(8.66)\} = 1460 \text{ IN}$$

$$l_2 = (7)\{160\} = 1120$$

$$\begin{array}{r} 1120 \\ 1460 \\ \hline 2580 \end{array}$$

TOTAL LENGTH = 1120 + 1460 = 2580 IN.

TOTAL VOLUME INCREASE

$$(2580)(.25) = 650 \text{ IN}^3$$

NOTE THAT RIBS CORRESPONDING TO l_2 ARE ALSO INCREASED IN AREA, ALTHOUGH COMPUTATION FOR RIB LOAD, F, p.9, ONLY CONSIDERED RIBS CORRESPONDING TO l_1. FROM INSPECTION RIBS CORRESPONDING TO l_2 WILL TAKE SOME OF THE LOAD

CONSIDERING P_1 RIBS (6 FINGERS) (REF p.2)

$P_1 = 305{,}000$ lb (REF p.3)

AVERAGE LOAD PER FINGER

$$P_A = \frac{305000}{6}$$

$P_A = 51{,}000$ lb

AREA TO BE ADDED TO RIBS

$$A = \frac{51{,}000}{43{,}500}(.25) \qquad \text{(REF p.9)}$$

$A = .30$ IN.^{2}

LENGTH OF RIBS FOR AREA INCREASE (REF p 8)

$l_1 = (2)(6)\{(6)(8.66)\} = 624$ IN.

$l_2 = (7)(70) = 490$ IN.

$624 + 490 = 1114$

TOTAL LENGTH $= 624 + 490 = 1114$ IN

TOTAL VOLUME INCREASE

$V = (1114)(.30)$

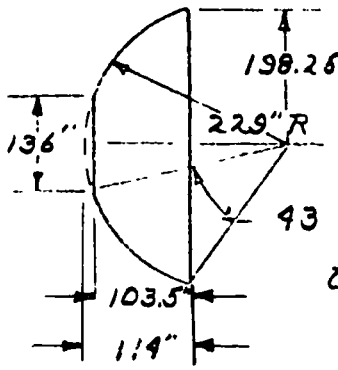
$V = 342$ IN^3

NOTE: CONSIDER $V = 342$ IN^3 ADDED ALSO TO CORRESPONDING P_1 STRUCTURE ON OTHER SIDE, FOR PRELIMINARY SIZING.

AFT BULKHEAD - LH_2 TANK

SHELL

PRESSURE = 33.9 PSI LIMIT
= 1.5(33.9) = 50.8 PSI ULTIMATE



$\sigma_{tu} = 63{,}000\ (1.07)^{*} = 67{,}400$ PSI

* GUARANTEED TYPICAL FACTOR

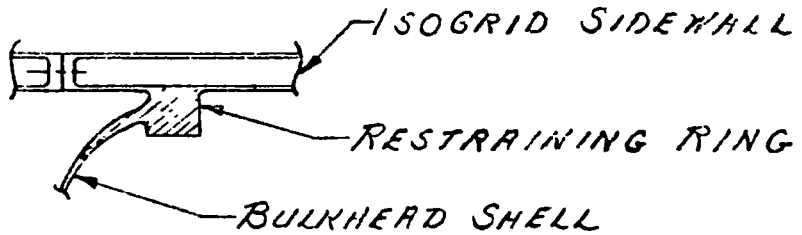
$$t = \frac{PR}{2\sigma} = \frac{50.8(229)}{2(67{,}400)} = 0.086 \text{ MIN}$$

$= 0.091$ NOM ± 0.005

AREA $= 2\pi RH = 2\pi(229)103.5 = 149{,}000\ IN^2$

SHELL WEIGHT $= A\ell\rho = 149{,}000(0.091)0.102 =$ **1,383 LBS**

RESTRAINING RING



TYPICAL JOINT

$R_o = 198.25$
$\rho = 0.102\ LB/IN^3$
$P = 33.9$ PSIA
F.S. $= 1.5$
$\sigma_{tu} = 67{,}400$ PSI *
$H = 114$ IN

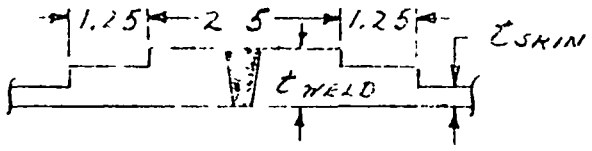
* TEST DATA FROM THE THOR-DELTA PROGRAM INDICATE THAT BUCKLING ALLOWABLES SHOULD BE CLOSE TO THE TENSILE ULTIMATE.

$$\text{RING WT} = \frac{\pi R_o^3 \rho P}{\sigma}\left[\frac{1-\left(\frac{H}{R_o}\right)^2}{2\left(\frac{H}{R_o}\right)}\right] \text{F.S.} =$$

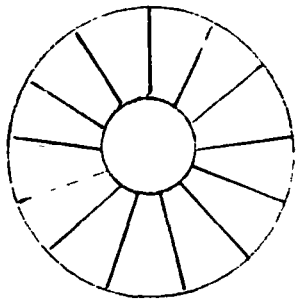
1,096 LBS

AFT BULKHEAD - LH_2 TANK (CONT)

WELD LAND PENALTY



TYPICAL WELD



13 SEGMENTS

$t_{WELD} = 2.8\ t_{SKIN}$

$$\text{WELD LENGTH} = 13\pi(229)\left(\frac{86}{360}\right) + 2\pi(198.25)$$

$$= 3,475 \text{ IN}$$

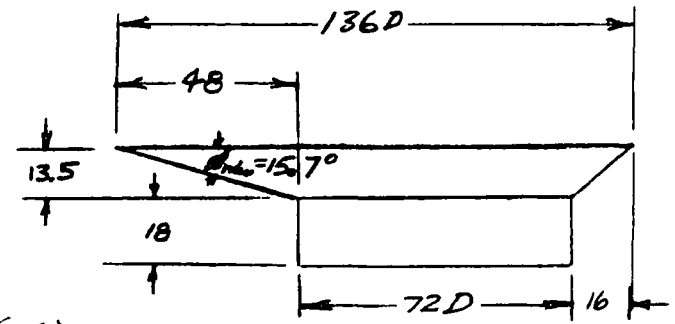
$$\text{WELD WEIGHT} = 3.75(2.8\ t_{SKIN} - t_{SKIN})\,L\,\rho$$

$$= 3.75[(1.8)(0.091)](3,475)\,0.102 = \boxed{218 \text{ LBS}}$$

LH_2 SUMP

	WEIGHT (LB)
CONICAL SEGMENT	223 (CALCULATION THIS PAGE)
CYLINDER	74 (CALCULATION THIS PAGE)
BOTTOM PLATE	114 (CALCULATION NEXT PAGE)
WELDS	115 (CALCULATION NEXT PAGE)
SUMP WEIGHT	526 LB

CONICAL SEGMENT



$R_\phi = \infty$

$R_t = 229$ (max)

$P_{ULT} = 50.8$ psi

$\sigma_{ULT} = 67{,}500$

$$N_\phi = \frac{\rho R_\phi}{2 \cos\phi_{cone}} = \frac{50.8\left(\frac{136}{2}\right)}{2 \sin 15.7} = 6390\ \#/in$$

$$\rho = \frac{N_\phi}{R_\phi} + \frac{N_t}{R_t}$$

$R_\phi = \infty$,

$$N_t = \rho R_t = 50.8 \times 229 = 11{,}620\ \#/in$$

$$t = \frac{N_t}{\sigma_{ULT}} = \frac{11{,}620}{67{,}500} = .173" \rightarrow .178 \pm .005$$

$S_{FLAT\ PLATE} = \frac{\pi}{4}(136)^2 - \frac{\pi}{4}(72)^2 = 14{,}530 - 4070 = 10{,}460\ in^2$

CORRECTION FACTOR $= \frac{1}{2}\frac{50}{48} + \frac{1}{2}\frac{21}{16} = .521 + .657 = 1.178$

$S_{CONE} = 1.178 \times 10{,}460 = 12{,}300\ in^2$

$W_{CONE} = S t \rho = 12{,}300 \times .178 \times .102 = 223\ \#$

CYLINDER

ASSUME $t = .178$

$W = \pi D L t \rho = \pi\ 72 \times 18 \times .178 \times .102 = 74\ \#$

LH2 SUMP (CONTINUED)

BOTTOM PLATE

(ROARK p194) $\sigma = \frac{3W}{8\pi m t^2}(3m+1)$, $m = \frac{1}{\mu}$, $W = \rho \pi r^2 = 50.8\pi(36)^2$

$W = 207{,}000$

$t = \sqrt{\frac{3W\mu}{8\pi\sigma}\left(\frac{3}{\mu}+1\right)} = \sqrt{\frac{3 \times 207{,}000 \times .3}{8\pi\, 67{,}500}\left(\frac{3}{.3}+1\right)}$

$t = \sqrt{1.21} = 1.10''$

$\bar{t}/t = .25$ (1/3 to 1/5 O.P. HARWOOD)

$\bar{t} = .25 \times 1.10 = \underline{.275}$

$W = S\bar{t}\rho = \pi r^2 \bar{t}\rho = \pi(36)^2(.275)(.102) = \underline{\underline{114^{\#}}}$

WELDS

$w = 4''$, $\Delta t = 1.8 \times .178 = .32$

$L = \pi 136 + 2(\pi 72) = 880''$

$W = L w \Delta t \rho = 880 \times 4 \times .32 \times .102 = \underline{\underline{115^{\#}}}$

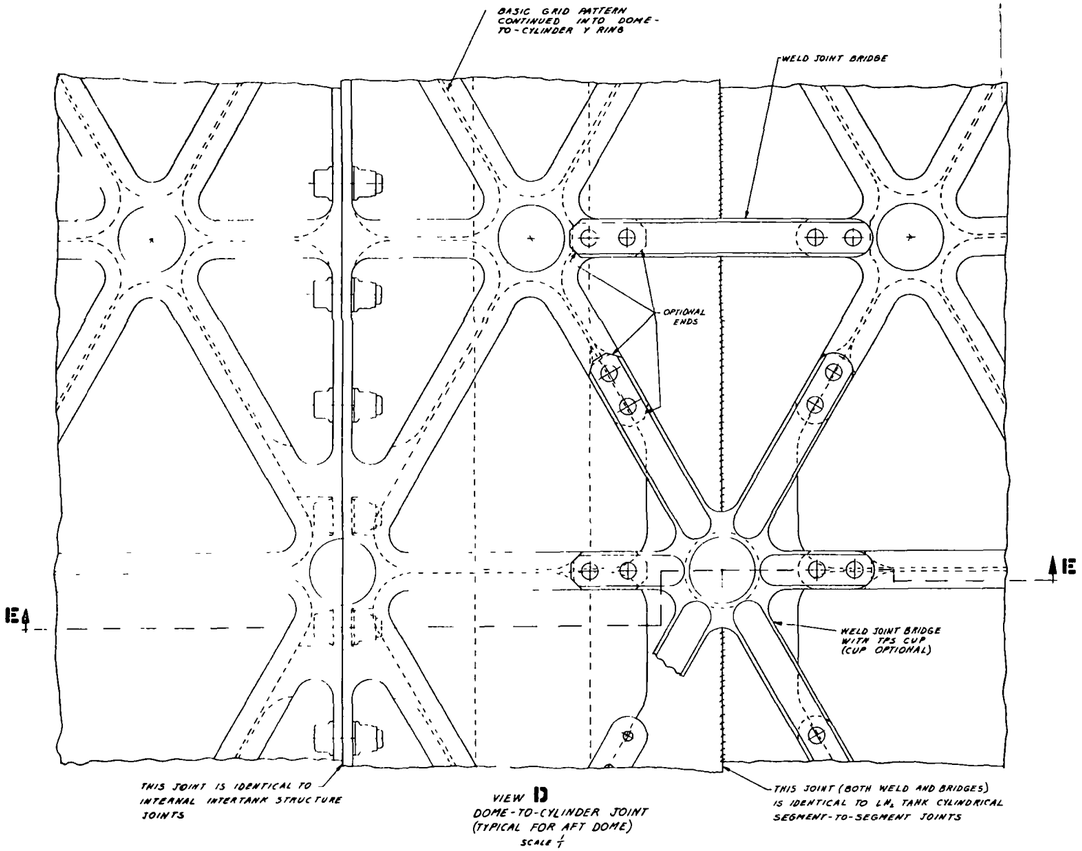
BAFFLES - LH2 TANK

WT = RL

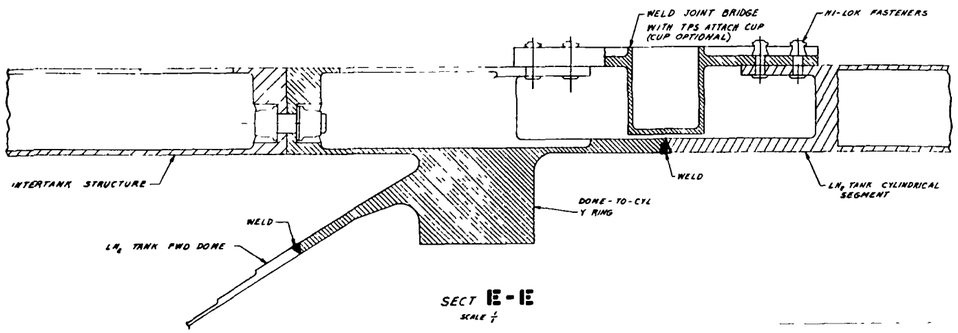
R = TANK RADIUS - FT

L = TANK LENGTH - FT

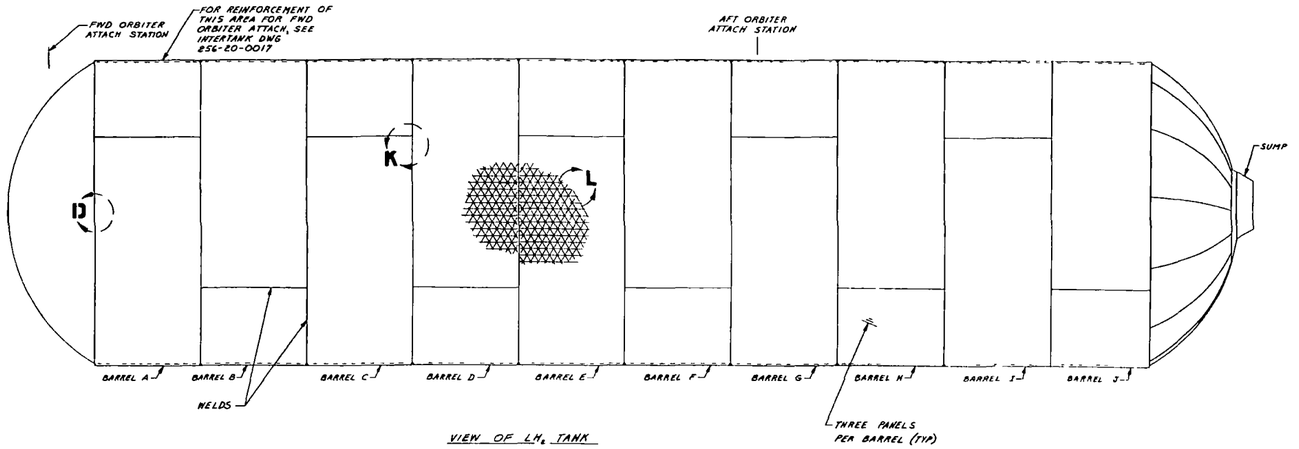
WEIGHT = 16.5 (115.8) = $\boxed{1{,}910 \text{ LB}}$



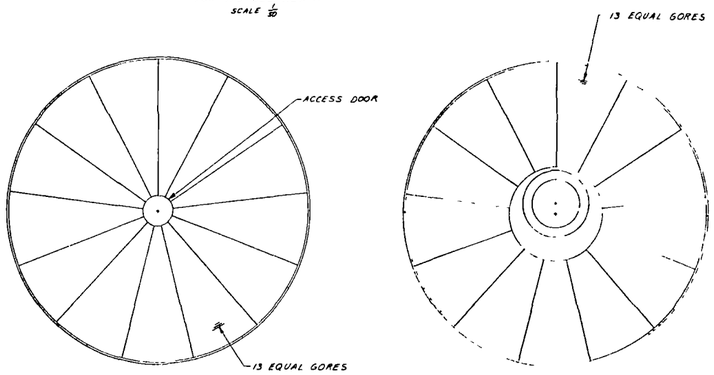
VIEW D
DOME-TO-CYLINDER JOINT
(TYPICAL FOR AFT DOME)
SCALE 1/1



SECT E-E
SCALE 1/1



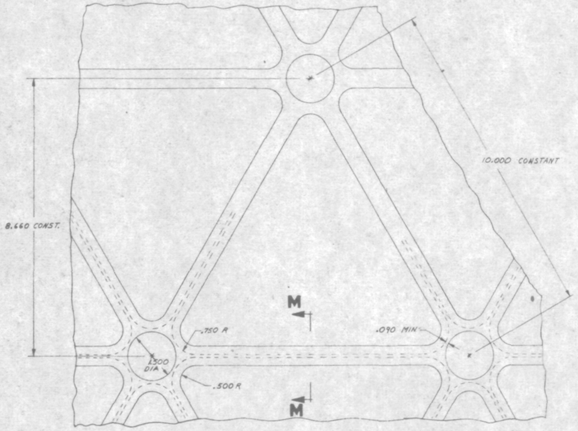
VIEW OF LH_2 TANK
THERMAL PROTECTION SYSTEM (TPS) OMITTED FOR CLARITY
FOR TPS SEE VIEW A
SCALE 1/50



A CHANGE
1 REVISED NOMINAL WAFFLE GEOMETRY
2 REDUCED SIZE OF NODES
3 MOVED JOINT BOLTS CLOSER TO INSIDE OF TANK
4 REMOVED VIEW OF TPS SUPPORT

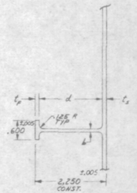
PREVIOUSLY RELEASED AS 256 14 0008

CONTRACT NO	MCDONNELL DOUGLAS ASTRONAUTICS CO.
ORIGINAL DATE 70-11-17	LAYOUT – MAIN LH_2 TANK ASSY
	SIZE / CODE IDENT NO 18355 / DRAWING NO 256-20-0013
	SCALE NOTED / SHEET 1 OF 2
	REVISED 71-6-9



VIEW L
TYPICAL INTEGRAL WAFFLE
SCALE f

NOTE: OTHER VIEWS ARE SLIGHTLY OUT-OF-SCALE.



SECT. M-M

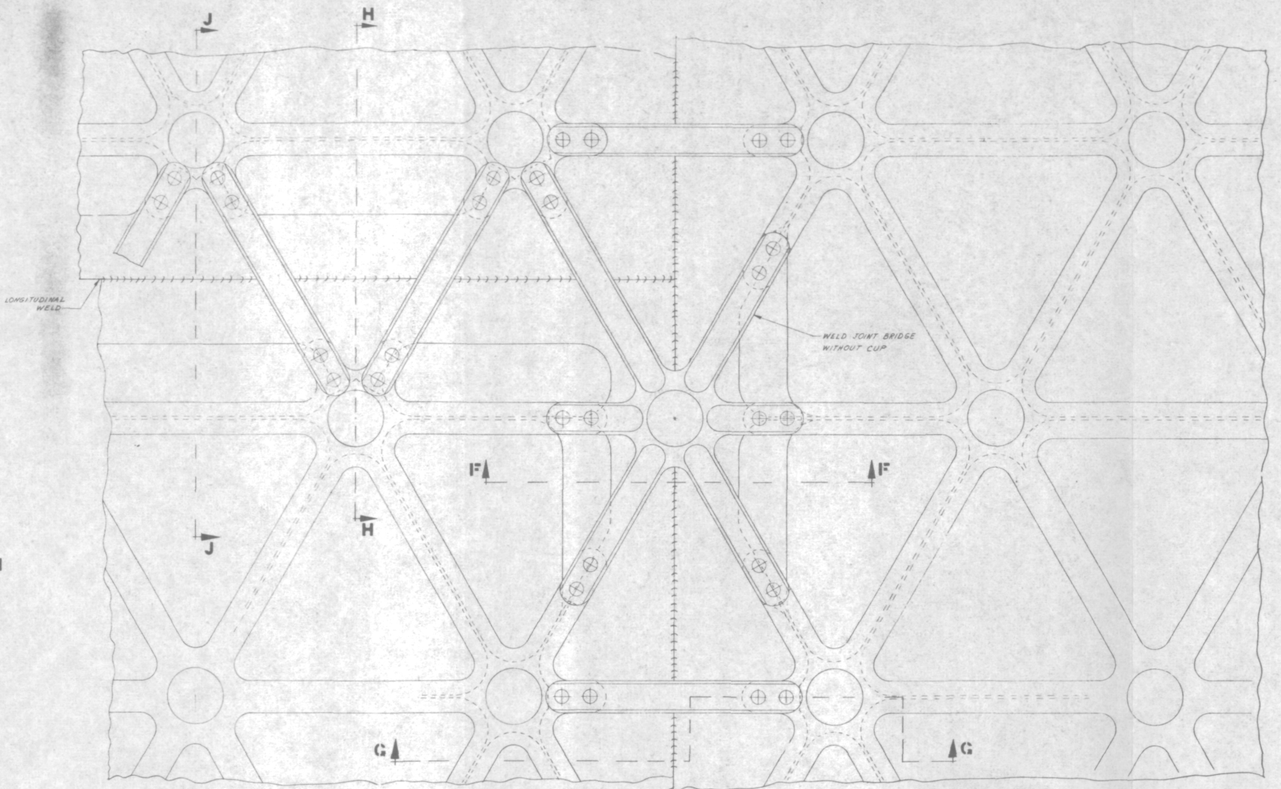
BARREL #	MAX. COMPR. LOAD, LB/LIN.	CYL. LENGTH IN.	t_1 ±.005 IN.	t_2 ±.005 IN.	d (REF) IN.	t_3 ±.005 IN.
A	8,550	190	.159	.089	1.861	.230
B	7,850		.139	.081	1.929	.172
C	7,670		.133	.081	1.936	.161
D	8,470		.158	.083	1.873	.215
E	9,500		.162	.085	1.815	.273
F	10,340		.167	.088	1.737	.346
G	10,700		.168	.088	1.729	.358
H	9,530		.163	.085	1.813	.279
I	8,530	190	.138	.083	1.882	.210
J	8,500	130	.137	.083	1.884	.209

NOMINAL DIMENSIONS FOR INTEGRAL WAFFLE
(*SEE MAIN VIEW)

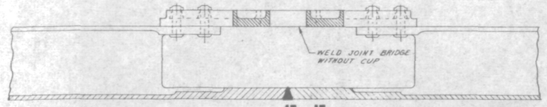
TABLE I

SECT. J-J

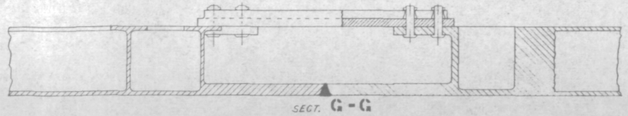
SECT. H-H



VIEW K
TYPICAL WELD JOINTS



SECT. F-F



SECT. G-G

LAYOUT - MAIN
LH_2 TANK ASSY.
18355
ESE-20-0013

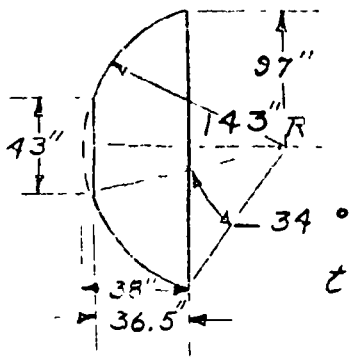
WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
② OXIDIZER TANK (LOX)		[19769]
FWD BULKHEAD		(300)
SHELL	40	124
RESTRAINING RING	40	105
WELD LAND	41	30
ACCESS DOOR	41	41
SIDEWALL		(9952)
ISOGRID SIDEWALL	42	9191
WELD LAND	44	761
AFT BULKHEAD		(4107)
SHELL	47	2003
RESTRAINING RING	47	1512
WELD LAND	48	257
SUMP	49 TO 57	335
CONTINGENCY - 5 %		(720)
BAFFLES	57	(4650)

FWD BULKHEAD - LOX TANK

SHELL

PRESSURE = 210 PSI LIMIT
= 1.5(21.0) = 31.5 PSI ULTIMATE



$\sigma_{cu} = 63{,}000\,(1.07)^{*}(1.04)^{**} = 70{,}200$ PSI

* GUARANTEED TYPICAL FACTOR

** TEMP. CORRECTION @ - 300°F

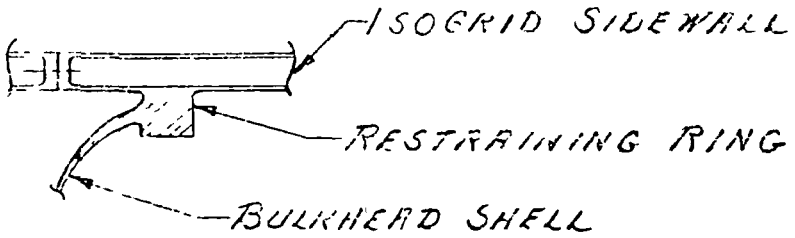
$$t = \frac{PR}{2\sigma} = \frac{31.5(143)}{2(70{,}200)} = 0.032 \text{ MIN}$$

$= 0.037$ Nom ± 0.005

AREA $= 2\pi RH = 2\pi(143)36.5 = 32{,}800$ IN^2

SHELL WEIGHT $= AtP = 32{,}800(0.037)0.102 =$ **124 LBS**

RESTRAINING RING



TYPICAL JOINT

$R_o = 97$ IN
$\rho = 0.102$ LB/IN^3
$P = 21.0$ PSI
F.S. $= 1.5$
$\sigma_{cu} = 70{,}200$ PSI *
$H = 38$ IN

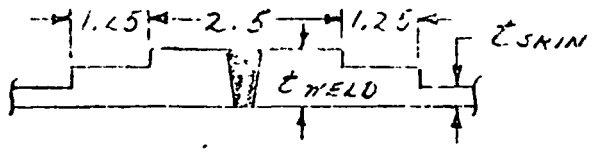
* TEST DATA FROM THE THOR-DELTA PROGRAM INDICATE THAT BUCKLING ALLOWABLES SHOULD BE CLOSE TO THE TENSILE ULTIMATE

$$\text{RING WT} = \frac{\pi R_o^3 \rho P}{\sigma}\left[\frac{1-\left(\frac{H}{R_o}\right)^2}{2\left(\frac{H}{R_o}\right)}\right] \text{F.S.} = 142\left(\frac{.796}{.1083}\right) = \boxed{105 \text{ LBS}}$$

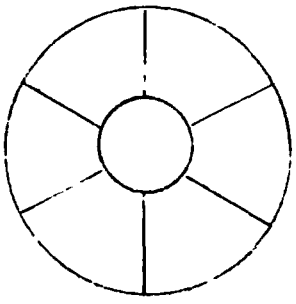
← SLOPE [illegible]

FWD BULKHEAD - LOX TANK (CONT)

WELD LAND PENALTY



TYPICAL WELD.



6 SEGMENTS

$t_{WELD} = 2.8\ t_{SKIN}$

$$\text{WELD LENGTH} = 6\pi(143)\left(\frac{68}{360}\right) + 2\pi\left(97 + \frac{43}{4}\right)$$

$$= 1{,}183 \text{ IN}$$

$$\text{WELD WEIGHT} = 375(2.8\ t_{SKIN} - t_{SKIN})LP$$

$$= 375[(1.8)(0.037)](1{,}183)0.102 = \boxed{50 \text{ LBS}}$$

TANK - ACCESS PROVISIONS

THE WEIGHT OF THE TANK ACCESS DOOR IN THE FORWARD BULKHEAD IS BASED ON THE 43 INCH DIAMETER DOOR IN THE S-IVB LH_2 TANK FORWARD BULKHEAD.

S-IVB DATA

BULKHEAD SKIN THICKNESS = 0.060 INCH

WEIGHT:

DOOR =	37 LB
ATTACH FLANGE =	29 LB
TOTAL	66 LB

SHUTTLE DOOR WEIGHT

BULKHEAD SKIN THICKNESS = 0.037 INCH

$$\text{WEIGHT} = \frac{0.037}{0.060}(66) = \boxed{41 \text{ LB}}$$

LOX TANK SIDEWALL

SPAN	r IN	R IN	H IN	ρ LB/IN³	$\bar{t}_{NOM}$ * ±0.005" t_1	t_2	WEIGHT LB	C G STA
STA 1230 - 1271	97 1	108.9	41	0.102	.0782	.0782	220	1251
STA 1271 - 1312	108 9	122.1	41		.0808	.0808	258	1292
STA 1312 - 1352	122.1	132.1	40		.0850	.0850	285	1332
STA 1352 - 1393	132 1	141.4	41		.0861	0861	317	1373
STA 1393 - 1435	141 4	150.6	42		.0895	.0895	360	1414
STA 1435 - 1476	150.6	160.1	41		.0929	.0929	389	1456
STA 1476 - 1518	160.1	167.4	42		.0950	0950	425	1497
STA 1518 - 1560	167.4	174.7	42		.0970	0970	453	1539
STA 1560 - 1603	174 7	182.2	43		1060	.1060	529	1582
STA 1603 - 1646	182.2	187.5	43		.1186	1186	609	1625
STA 1646 - 1689	187.5	192.9	43		1314	.1314	694	1668
STA 1689 - 1733	192 9	198.5	44		.1447	1447	805	1711
STA 1733 - 1783	198.5	198 5	50		1574	.1574	1,001	1758
STA 1783 - 1833	198 5	198.5	50		.1701	.1701	1,082	1808
STA 1833 - 1883	198.5	198.5	50	0.102	1829	1829	1,163	1858
SIDEWALL							8,590	1638
NODAL PENALTY 7%							601	1638
TOTAL SIDEWALL (LESS WELD LAND PENALTY)							9,191 **	16

* SEE $\bar{t}$ CALCULATIONS ON PAGE 2.3-45

** WEIGHT REPRESENTS SIDEWALL DESIGNED FOR A COMBINATION OF FLIGHT LOADS & PROOF TEST LOADS. INCLUDES 573 POUND PENALTY FOR SIMULATED PRESSURE GRADIENT. PENALTY IS THE DIFFERENCE BETWEEN SIDEWALL CALCULATED FOR FLIGHT LOADS ONLY (SEE PAGE 2.3-43) AND ABOVE (9,191 - 8,618 = 573 LB)

LOX TANK SIDEWALL

SPAN	r IN	R IN	H IN	ρ LB/IN³	t NOM ±0.005" t_1	t NOM ±0.005" t_2	WEIGHT LB	C. G. STA
STA 1230 – 1271	97.1	108.9	41	0.102	.0782	.0782	220	1251
STA 1271 – 1312	108.9	122.1	41		.0308	.0808	258	1292
STA 1312 – 1352	122.1	132.1	40		.0850	.0850	285	1332
STA 1352 – 1393	132.1	141.4	41		.0861	.0861	317	1373
STA 1393 – 1435	141.4	150.6	42		.0895	.0895	360	1414
STA 1435 – 1476	150.6	160.1	41		.0929	.0929	389	1456
STA 1476 – 1518	160.1	167.4	42		.0950	.0950	426	1497
STA 1518 – 1560	167.4	174.7	42		.0990	.0990	463	1539
STA 1560 – 1603	174.7	182.2	43		.0992	.0992	495	1582
STA 1603 – 1646	182.2	187.5	43		.1094	.1094	562	1625
STA 1646 – 1689	187.5	192.9	43		.1206	.1206	637	1668
STA 1689 – 1733	192.9	198.5	44		.1319	.1319	734	1711
STA 1733 – 1783	198.5	198.5	50		.1416	.1416	901	1758
STA 1783 – 1833	198.5	198.5	50		.1525	.1525	970	1808
STA 1833 – 1883	198.5	198.5	50	0.102	.1632	.1632	1,038	1858
							8,054	1630
SIDEWALL NODAL PENALTY 7%							564	1630
TOTAL SIDEWALL (LESS WELD LAND PENALTY)							8,618**	1630

* SEE t CALCULATIONS ON PAGE 2 3-46

** WEIGHT REQUIRED FOR FLIGHT LOADS ONLY

WELD LAND PENALTY - LOX TANK SIDEWALL

THE WELD LAND PENALTY IS BASED ON THE WELD LAND BEING 6.25 INCHES WIDE AT 2.8 TIMES THE NOMINAL SKIN THICKNESS THICK. EACH SECTION HAS ONE CIRCUMFERENTIAL WELD AND THREE LONGITUDINAL WELDS.

WELD LAND WT FOR SIDEWALL DESIGNED FOR A COMBINATION OF FLIGHT LOADS AND PROOF TEST LOADS

	WELD LENGTH	t_{SKIN} NOM	WEIGHT LB.	C.G STA
STA 1230 - 1352	$L = \pi(229) + 3(122) = 1,086''$	$WT = 6.25(1.8)(.051)(1,085)(.102) =$	64	1291
STA 1352 - 1476	$L = \pi(292) + 3(124) = 1,289''$	$WT = 6.25(1.8)(.066)(1,289)(.102) =$	98	1414
STA 1476 - 1603	$L = \pi(342) + 3(127) = 1,455''$	$WT = 6.25(1.8)(.079)(1,455)(.102) =$	132	1540
STA 1603 - 1733	$L = \pi(380.25) + 3(130) = 1,584''$	$WT = 6.25(1.8)(.114)(1,584)(.102) =$	207	1668
STA 1733 - 1883	$L = \pi(396.5) + 3(150) = 1,695''$	$WT = 6.25(1.8)(.154)(1,695)(.102) =$	300	1808
	WELD LAND PENALTY		801	1638

WELD LAND WEIGHT FOR SIDEWALL DESIGNED FOR FLIGHT LOADS ONLY

STA 1230 -1352	$L = 1,085''$	$WT = 6.25(1.8)(.051)(1,085)(.102) =$	64	1291
STA 1352 - 1476	$L = 1,289''$	$WT = 6.25(1.8)(.066)(1,289)(.102) =$	98	1414
STA 1476 - 1603	$L = 1,455''$	$WT = 6.25(1.8)(.077)(1,455)(.102) =$	129	1540
STA 1603 - 1733	$L = 584''$	$WT = 6.25(1.8)(.103)(1,584)(.102) =$	187	1668
STA 1733 - 1883	$L = 1,695''$	$WT = 6.25(1.8)(.136)(1,695)(.102) =$	265	1808
	WELD LAND PENALTY		743	1630

* WEIGHT INCLUDES 37 POUND PENALTY FOR SIMULATED PRESSURE GRADIENT. THIS IS THE DIFFERENCE BETWEEN THE TWO WELD LAND WEIGHTS (801 - 743 = 58 LB).

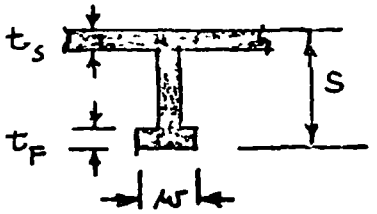
SUMMARY OF LOX TANK GRID DIMENSIONS

TABLE V

SUMMARY OF LOX TANK WAFFLE GRID DIMENSIONS

COMP.	STATION FROM	STATION TO	MONO. t_{min}	$S_{nom.}$ ±.005	$t_{s\ nom.}$ ±.005	$b_{nom.}$ ±.005	$t_{F\ nom.}$ ±.005	$w_{nom.}$ ±.005	$\bar{t}^{*}_{nom.}$	
1 FWD. CONE	1230	1271	.0498	1.00	.045	.056	0	0	.0782	
	1271	1312	.0552	↓	.051	↓	↓	↓	.0808	
	1312	1352	.0605	↓	.058	↓	↓	↓	.0850	THIS SECT. DESIGNED BY FLIGHT ULLAGE PRESSURE
2 FWD. MID CONE	1352	1393	.0638	↓	.061	↓	↓	↓	.0861	↓
	1393	1435	.0680	↓	.066	↓	↓	↓	.0895	↓
	1435	1476	.0723	↓	.071	↓	↓	↓	.0929	↓
3 FWD AFT CONE	1476	1518	.0748	↓	.074	↓	↓	↓	.0950	↓
	1518	1560	.0781	↓	.077	↓	↓	↓	.0970	↓
	1560	1603	.0879	↓	.087	↓	↓	↓	.1060	THIS SECT. DESIGNED BY PROOF PRESSURE
4 AFT CONE	1603	1646	.1003	↓	.098	↓	↓	↓	.1186	↓
	1646	1689	.1138	↓	.114	↓	↓	↓	.1314	↓
	1689	1733	.1282	1.00	.128	↓	0	0	.1447	↓
5 150" LONG CYL.	1733	1783	.1405	1.10	.139	↓	.125	.125	.1578	THIS SECT. DESIGNED BY FLIGHT COMP. AND PROOF PRESSURE
	1783	1833	.1542	1.10	.152	↓	.160	.125	.1701	↓
	1833	1883	.1685	1.20	.165	.055	.225	.125	.1829	↓

* LATEST MATERIAL REQ - SUPERCEDES INFORMATION ON DWG 1256-20-0012



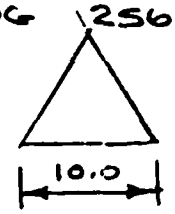


TABLE III LOX TANK WAFFLE GRID DIMENSIONS
FLIGHT PRESSURE LOAD COND. ONLY

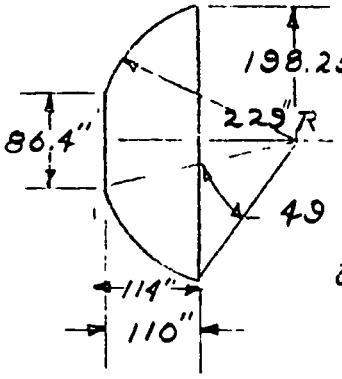
CONP	STATION FROM	STATION TO	r	P_{LIM}	P_{ULT}	TEMP °F	F_{TU} KSI	COS α	MONO I_{MIN}	$t_{s_{NOM}}$ ±.005	h NOM	b_{NOM} ±.005	d_{NOM} ±.005	$\frac{t}{t}$ NOM
1 FWD CONE	1230	1271	(97)	21.0	31.5	-100	71.5	.961	.0418	.045	4.741	.055	.955	.0702
	1271	1312		↑	↑	↑	↑	.961	.0552	.051	5.251	↑	.949	.0808
	1312	1352	132					961	.0605	.058	5.760		.942	.0850
2 FWD MID CONE	1352	1393						.975	.0638	.061	6.167		.939	.0861
	1393	1435						.975	.0680	.066	6.574		.934	.0895
	1435	1476	160			↓	↓	975	0723	.071	6.981		.929	.0929
3 FWD AFT CONE	1476	1518		↑	↑	-100	71.5	.985	.0745	.074	7.302		.926	.0950
	1518	1560		21.0	31.5	-297	80.2	.985	.0781	.077	7.621		.923	.0970
	1560	1603	182	23.25	34.8	↑	↑	.985	.0802	.080	7.941		.920	.0992
4 AFT CONE	1603	1646		25.75	38.6			992	.0909	.091	8.178		.909	.1094
	1646	1689		28.25	42.4			992	.1027	.103	8.414		.898	.1206
	1689	1733	198.25	30.80	46.2			992	.1150	.115	8.650		.885	.1319
5 CYL	1733	1783	198.25	33.30	50.6			1.000	.1250	.125	8.650		.875	.1416
	1783	1833		36.8	55.0	↓	↓	1.000	.1360	.136	8.650	↓	.864	.1525
	1833	1893	198.25	39.6	59.4	-297	80.2	1.000	.1468	.147	8.650	.055	.853	.1632

THE ABOVE TABLE PRESENTS THE REQUIRED ISOGRID DIMENSIONS AND AVERAGE WEIGHT THICKNESS $\frac{t}{t}$ USING MATERIAL PROPERTIES OF 2219 T87 AT CRYOGENIC TEMPERATURES (WITH A FACTOR OF 1.07 APPLIED TO $F_{TU\,MIN}$). DIMENSIONS WERE OBTAINED FROM OUTPUT OF COMPUTER PROGRAM "TEAR". SEE APPENDIX A FOR LISTING AND OUTPUT.

AFT BULKHEAD - LOX TANK

SHELL

PRESSURE = 51.3 PSI LIMIT
= 1.05(5.3) = 53.8 PSI ULTIMATE



$\sigma_{cy} = 51,000\,(1.07)^{*}(.95)^{**} = 51,800$ PSI

* GUARANTEED TYPICAL FACTOR

** 95 % OF YIELD

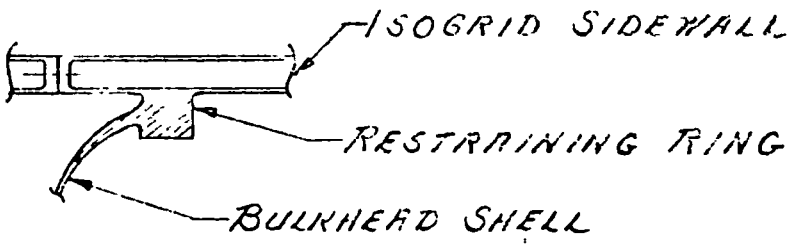
$$t = \frac{PR}{2\sigma} = \frac{53.8(229)}{2(51,800)} = 0.119 \text{ MIN}$$

$= 0.124$ NOM ± 0.005

$A_{PEN} = 2\pi RH = 2\pi(229)\,110 = 158,500$ IN^2

SHELL WEIGHT = $A_{PEN}\,t\,\rho = 158,500(0.124)0.102 =$ **2,003 LBS**

RESTRAINING RING



TYPICAL JOINT

$R_o = 198.25$"
$\rho = 0.102$ LB/IN^3
$P = 51.3$ PSI
F.S. = 1.05
$\sigma_{cy} = 51,800$ PSI *
$H = 114$ IN

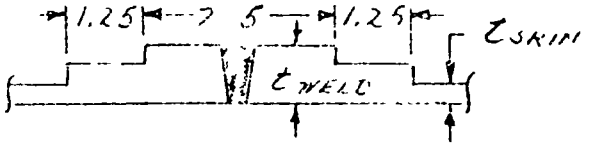
* TEST DATA FROM THE THOR-DELTA PROGRAM INDICATE THAT BUCKLING ALLOWABLES SHOULD BE CLOSE TO THE TENSILE ULTIMATE.

$$\text{RING WT} = \frac{\pi R_o^3 \rho P}{\sigma}\left[\frac{1-\left(\frac{H}{R_o}\right)^2}{2\left(\frac{H}{R_o}\right)}\right] \text{F.S.} =$$

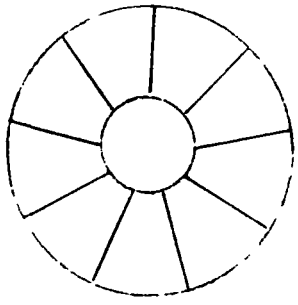
1,512 LBS

AFT BULKHEAD - LOX TANK (CONT.)

WELD LAND PENALTY



TYPICAL WELD



9 SEGMENTS

$t_{WELD} = 2.8\ t_{SKIN}$

$$\text{WELD LENGTH} = 9\pi(229)\left(\frac{98}{360}\right) + 2\pi(198.25)$$

$$= 3{,}003 \text{ IN}$$

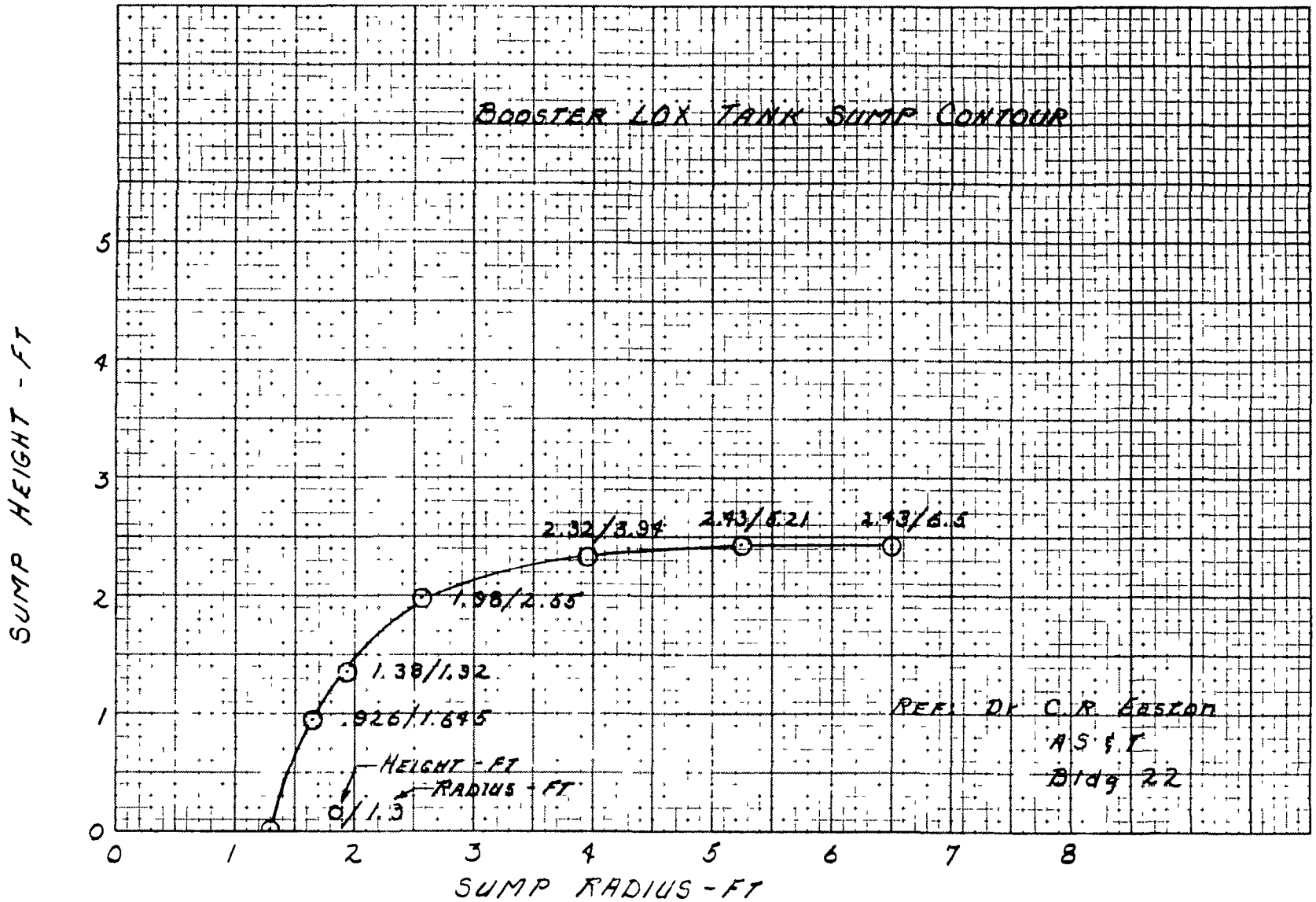
$$\text{WELD WEIGHT} = 3.75(2.8\ t_{SKIN} - t_{SKIN})LP$$

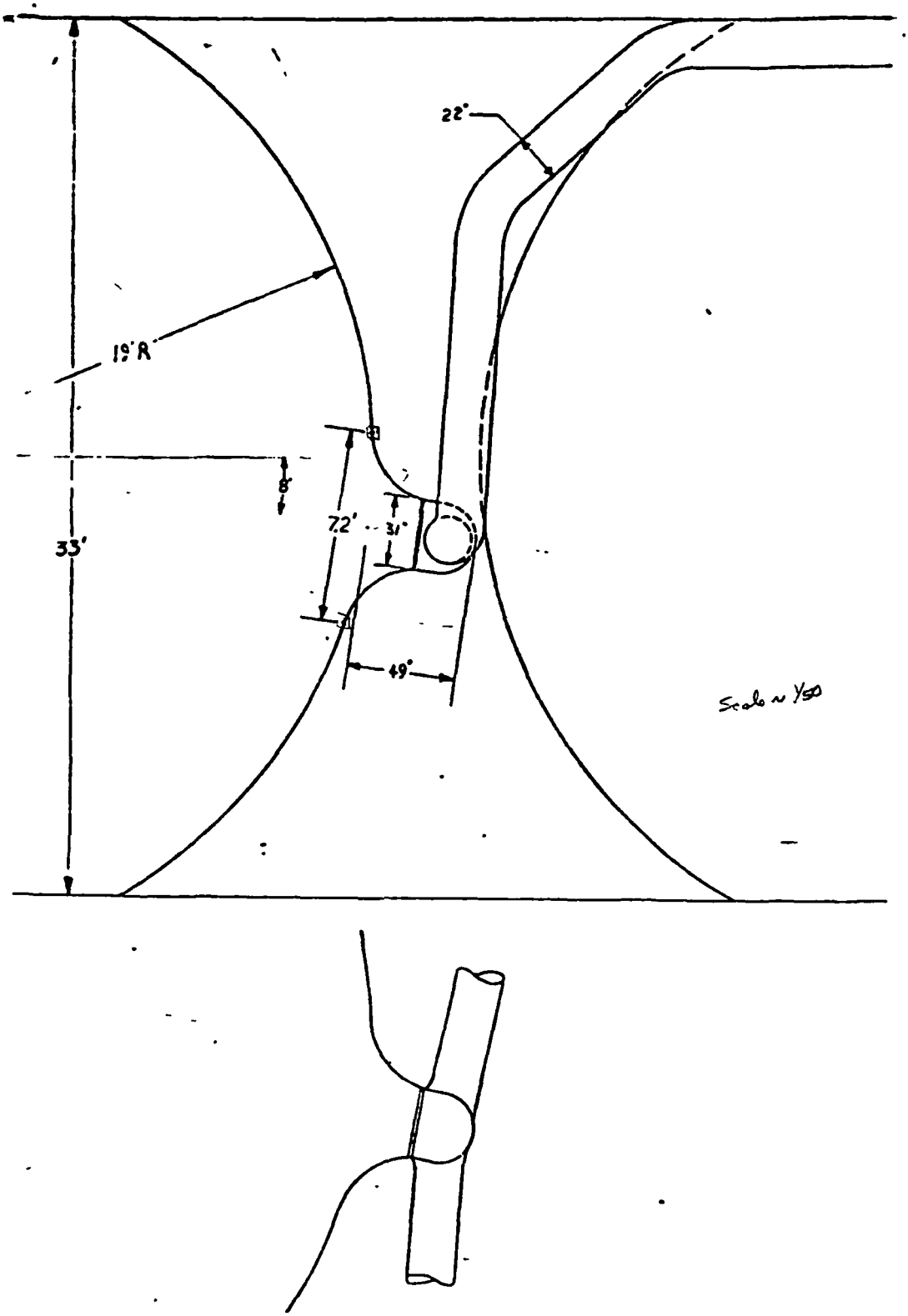
$$= 3.75[(1.8)(0.124)](3{,}003)0.102 = 257 \text{ LBS}$$

LOX TANK SUMP WEIGHT PENALTY

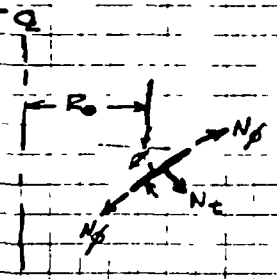
R_Θ (ft)	$\bar{R}_\Theta$ (ft)	$\bar{R}_\Theta$ (IN)	ϕ	Z_{MIN}	WT-LB
3.6-3.4	3.5	42.0	8.5°	1.480	96.7
3.4-3.2	3.3	39.6	12°	0.718	44.6
3.2-3.0	3.1	37.2	15°	0.453	26.9
3.0-2.8	2.9	34.8	19°	0.264	15.0
2.8-2.6	2.7	32.4	22°	0.196	10.5
2.6-2.4	2.5	30.0	25°	0.143	7.3
2.4-2.2	2.2	26.4	37°	0.100	10.1
SUBTOTAL					211.1
ADD 10% FOR TAPER & TOLERANCES					21.2
REMAINDER OF FORWARD SUMP SECTION					23.6
SUMP TO DOME JOINT PENALTY					52.3
AFT SECTION OF SUMP					26.1
TOTAL LOX SUMP WEIGHT PENALTY					334.3

335 LB


BOOSTER LOX TANK SUMP CONTOUR
SUMP HEIGHT - FT
SUMP RADIUS - FT
0
1
2
3
4
5
6
7
8
2.32/3.94
2.43/5.21
2.43/6.5
1.98/2.55
1.38/1.32
.926/1.645
0/1.3
HEIGHT - FT
RADIUS - FT
REF: Dr C.R. Easton
AS&T
Bldg 22


22°
19° R
8'
33'
72'
31'
49'
Scale ~ 1/50

SUMP – CONTOURED, LOW PULL THRU



$R_\phi \doteq -30''$

$p_{ult} = 73$ psi

* $N_\phi = \frac{p R_\theta}{2 \sin\phi}$ $\left(N_\phi = 37.5 \frac{R_\theta}{\sin\phi} \text{ if } p = 37.5\right)$

* $R_t = \frac{R_\theta}{\sin\phi}$

$N_t = \left(p - \frac{N_\phi}{R_\phi}\right) R_t$

$p = \frac{N_\phi}{R_\phi} + \frac{N_t}{R_t}$

$N_t = \left(p - \frac{N_\phi}{R_\phi}\right) R_t$

for $p = 73$ & $R_\phi = -30$

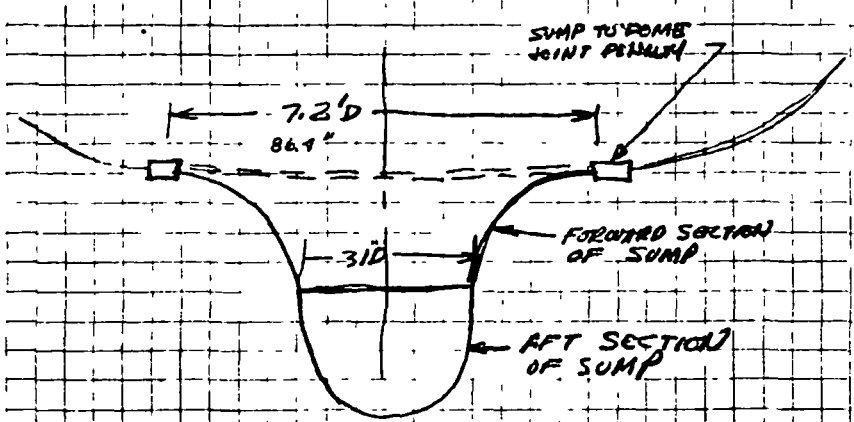
* $N_t = \left(73 + \frac{N_\phi}{30}\right) R_t$

WEIGHT EQUATION

* $w = 2\pi \bar{R}_\theta \, t \left(\frac{R-r}{\cos\phi}\right) \rho$

$\frac{R-r}{L} = \cos\phi$

$L = \frac{R-r}{\cos\phi}$



$R_o = 36 - 3.4$

$N\phi = \frac{\rho R_o}{2 \cos\phi} = \frac{73 \times 42}{2 \cos 8.1^\circ} = 10{,}400$ #/in

$R_t = \frac{R_o}{\cos\phi} = \frac{42}{\cos 8.5} = 284''$

$N_t = (73 + \frac{N\phi}{30}) R_t = (73 + \frac{10{,}400}{30}) 284 = (73+347) 284 = 119{,}000$ #/in

$t = \frac{N_t}{\sigma_{ar}} = \frac{119{,}000}{80{,}500} = 1.480''$ min

$W = 2\pi R_o t \left(\frac{e-r}{\cos\phi}\right) \rho = 2\pi\, 42 \times 1.48 \left(\frac{2.4''}{\cos 8.5^\circ}\right) .102 = 96.7$

$R_o = 3.4 - 3.2$

$N\phi = 37.5 \frac{R_o}{\cos\phi} = 37.5 \frac{39.6}{\cos 12} = 7140$ #/in

$R_t = \frac{39.6}{\cos 12^\circ} = 186$

$N_t = (73 + \frac{7140}{30}) 186 = (73+238) 186 = 311 \times 186 = 57800$ #/in

$t = \frac{N_t}{\sigma_{ar}} = \frac{57{,}800}{80{,}500} = .718$ min

$W = 2\pi\, 39.6 \times .718 \left(\frac{2.4}{\cos 12}\right) .102 = 44.6$ #

$R_o = 3.2 - 3.0$

$N\phi = 37.5 \frac{37.2}{\cos 15} = 5400$ #/in

$R_t = \frac{37.2}{\cos 15^\circ} = 144''$

$N_t = (73 + \frac{5400}{30}) 144 = (73+180) 144 = 253 \times 144 = 36{,}500$ #/in

$t = \frac{36{,}500}{80{,}500} = .453$ min

$W = 2\pi\, 37.2 \times .453 \left(\frac{2.4}{\cos 15^\circ}\right) .102 = 26.9$ #

$R_o = 3.0 - 2.8$

$N\phi = 37.5 \frac{34.8}{\sin 180} = 4010\ ^{\#}/_{in}$

$R_t = \frac{R_o}{\sin\phi} = \frac{34.8}{\sin 90} = 107$

$N_t = (73 + \frac{4010}{30})107 = (73+134)107 = 207 \times 107 = \underline{22,200\ ^{\#}/_{in}}$

$t = \frac{22,200}{80,500} = .264$ min

$W = 2\pi(34.8).264(\frac{2.4}{\sin 180}).102 = \underline{15.0^{\#}}$

$R_o = 2.8 - 2.6$

$N\phi = 37.5 \frac{32.4}{\sin 22} = 3250\ ^{\#}/_{in}$

$R_t = \frac{32.4}{\sin 22} = 86.4$

$N_t (73 + \frac{3250}{30})86.4 = (73+109)86.4 = 182 \times 86.4 = 15,700\ ^{\#}/_{in}$

$t = \frac{15.700}{80,500} = \underline{.196}$

$W = 2\pi(32.4).196(\frac{2.4}{\sin 22}).102 = \underline{10.5^{\#}}$

$R_o = 2.6 - 2.4$

$N\phi = 37.5 \frac{30.0}{\sin 25} = 2660\ ^{\#}/_{in}$

$R_t = \frac{30.0}{\sin 25} = 71$

$N_t = (73 + \frac{2660}{30})71 = (73+88.7)71 = 161.7 \times 71 = \underline{11,500\ ^{\#}/_{in}}$

$t = \frac{11,500}{80,500} = .143$

$W = 2\pi(30.0)(.143)(\frac{2.4}{\sin 25}).102 = \underline{7.3^{\#}}$

REMAINDER OF SUMP – FORWARD SECTION

$R_o = 2.0' \text{ to } -1.3'$
$H = 1.15' \text{ to } 0$
} See "Booster LOX Tank sump contours" graph

$W = 2\pi \bar{R}_o \angle t \rho = 2\pi (1.6' \times 12''/ft)(1.6' \times 12''/ft) .1 \times .102$

$W = 23.6^{\#}$

$R_o = 2.4 - 2.0$

$N\phi = 37.5 \frac{26.4}{\sin 37^\circ} = 1645$

$Z_t = \frac{26.4}{\sin 37^\circ} = 43.9$

$N_t = (73 + \frac{1645}{30}) 43.9 = (73+55) 43.9 = 128 \times 43.9 = 5620$

$\sigma = \frac{5620}{60,500} = .070 \sim .100$ min gage (.090 min for 132" duct)

$W = 2\pi 26.4 \times .070 (\frac{4.8}{\cos 37^\circ}) .102 = 10.1^{\#}$

SUMP TO DOME JOINT

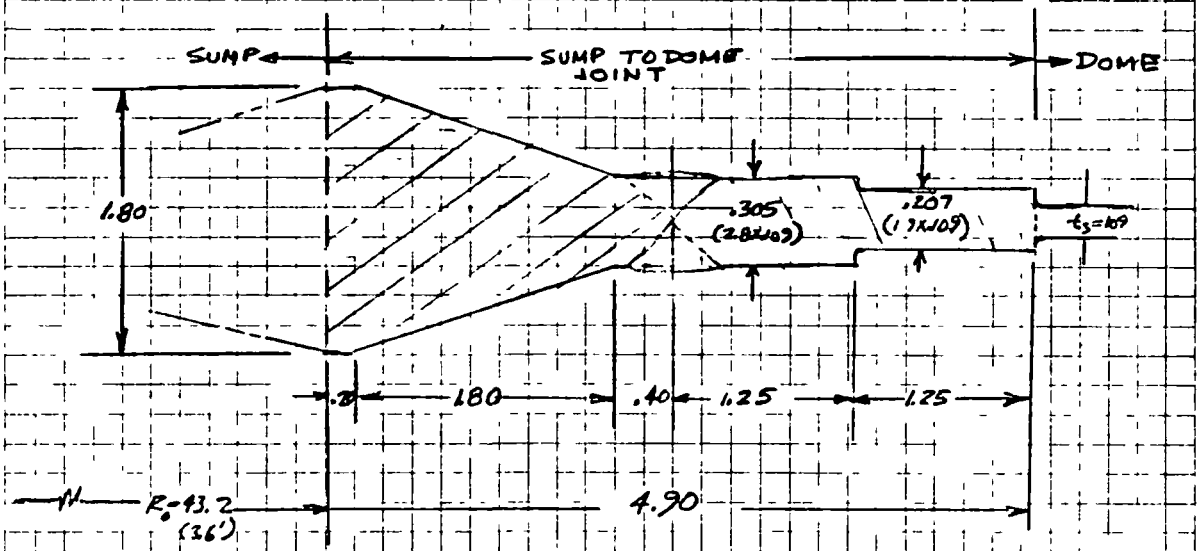
$R_o = 36'$

$N_\phi = 37.5 \frac{3.6 \times 12}{\cos 8^\circ} = 116.50^{\#}/in$

$R_t = \frac{3.6 \times 12}{\cos 8^\circ} = 311''$

$N_t = (73 + \frac{116.50}{30})311 = (73 + 3.9)311 = 462 \times 311 = 143,500$

$t = \frac{143,500}{80,500} = 1.78'' \sim 1.80 \pm .02$



$A_{TOTAL} = 1.80 \times .20 + 1.495(\frac{1}{2})1.80 + .305 \times 1.25 + .207 \times 1.25$

$A_{TOTAL} = .360 + 1.345 + .381 + .258 = \underline{2.344}$

$W_{TOTAL} = 2\pi \bar{R} A_{TOTAL} \rho = 2\pi(45.2)(2.344).102 = \underline{67.9^{\#}}$

$W_{DOME\ REMOVED} = 2\pi \bar{R} L t_s \rho = 2\pi\ 45.65 \times 4.90 \times .109 \overset{\times.102}{=} \underline{15.6^{\#}}$

$W_{NET\ SUMP\ TO\ DOME\ JOINT} = 67.9 - 15.6 = \underline{52.3^{\#}}$

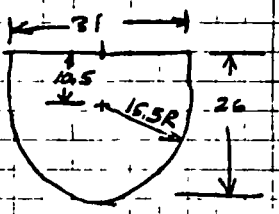
AFT SECTION OF SUMP

$t = \frac{PR}{\sigma} = \frac{72 \times 15.5}{80{,}500} = .014 \sim .100$ (t min gage)

$S = 2\pi R^2 + \pi DL = 2\pi(5.5)^2 + \pi(31)(0.5)$

$S = 1505 + 1055 = 2560$ in²

$W = Stf = 2560 \times .1 \times .102 = 26.1$ #



BAFFLES - LOX TANK

$WT = 7.0\,RL$

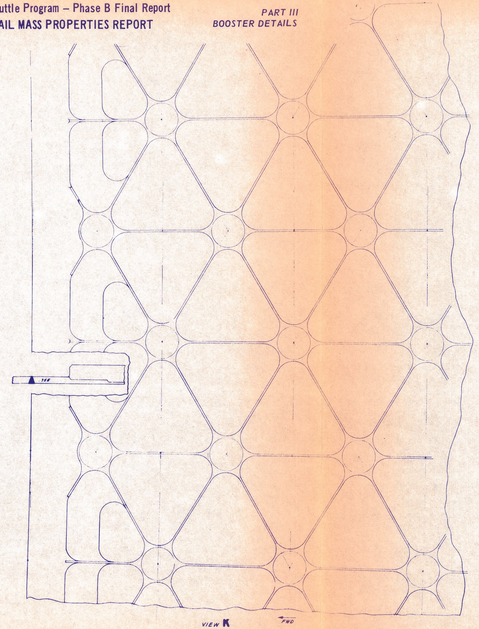
R = AVERAGE TANK RADIUS - FT

L = TANK LENGTH - FT

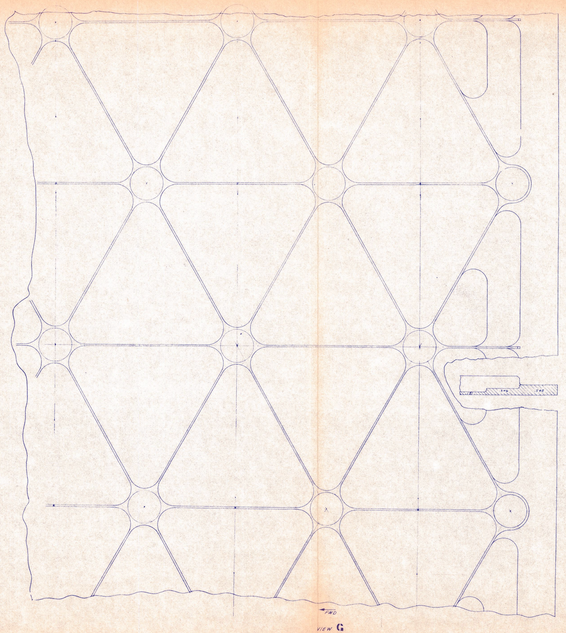
$R = \frac{137 + 198.25}{2} = 147.63'' = 12.3$ FT

$L = 653'' = 54.4$ FT

WEIGHT $= 7.0(12.3)(54.4) =$ **4,650 LB**



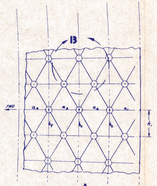
VIEW **K**
FLAT PATTERN OF
FWD. END OF FWD. MID CONE
SCALE $\frac{1}{4}$



VIEW **G**
FLAT PATTERN OF AFT
END OF AFT CONE
SCALE $\frac{1}{4}$

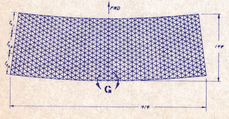
FLAT PATTERN OF
ONE SEGMENT OF FWD. CONE
SCALE $\frac{1}{16}$

FLAT PATTERN OF ONE SEGMENT
OF FWD MID CONE
SCALE $\frac{1}{16}$

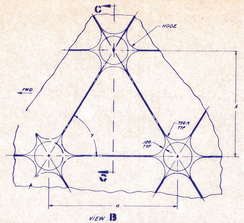


VIEW **A**
TYPICAL FLAT PATTERN OF INTEGRAL
WAFFLE SHOWING TAPER OF
TRIANGLES

FLAT PATTERN OF ONE SEGMENT
OF AFT MID CONE
SCALE $\frac{1}{16}$



FLAT PATTERN OF ONE SEGMENT
OF AFT CONE
SHOWING TRIANGULAR WAFFLE PATTERN
SCALE $\frac{1}{16}$



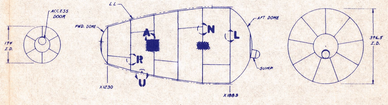
VIEW **B**
TYPICAL WAFFLE GEOMETRY
SCALE 1
NOTE: OTHER VIEWS ARE SLIGHTLY OUT-OF-SCALE.

SECT. **C-C**

NOMINAL WAFFLE GEOMETRY

CONE	SEG	t								
		MAX	MIN							
FWD CONE	-0134-403 thru -0134-406	4.94	4.44	.50	4.69	4.19	3	40.0	.190	.160
	-0134-1001 thru -0134-1004								.188	
FWD MID CONE	-0135-1001 thru -0135-1004	4.82	4.31	.51	4.56	4.05	3	38.0	.190	.160
	-0135-1005 thru -0135-1008								.191	
AFT MID CONE	-0136-401 thru -0136-404	3.98	3.48	.50	3.73	3.23	3	30.0	.190	.160
	-0136-1001 thru -0136-1004								.178	
AFT CONE	-0137-401 thru -0137-404	3.73	3.19	.54	3.46	2.92	3	27.0	.190	.160
	-0137-1001 thru -0137-1004								.168	
	-0137-1005 thru -0137-1008								.162	
AFT CONE	-0138-401 thru -0138-404	3.73	3.19	.54	3.46	2.92	3	27.0	.190	.160
	-0138-1001 thru -0138-1004								.178	
	-0138-1005 thru -0138-1008								.162	
CYL	-1001 thru -1004	0.90	0.40	.50	0.65	0.15	3	6.0	.190	.160
	-1005 thru -1008								.156	
	-1009 thru -1012								.152	

MATERIAL EXCEPTIONS



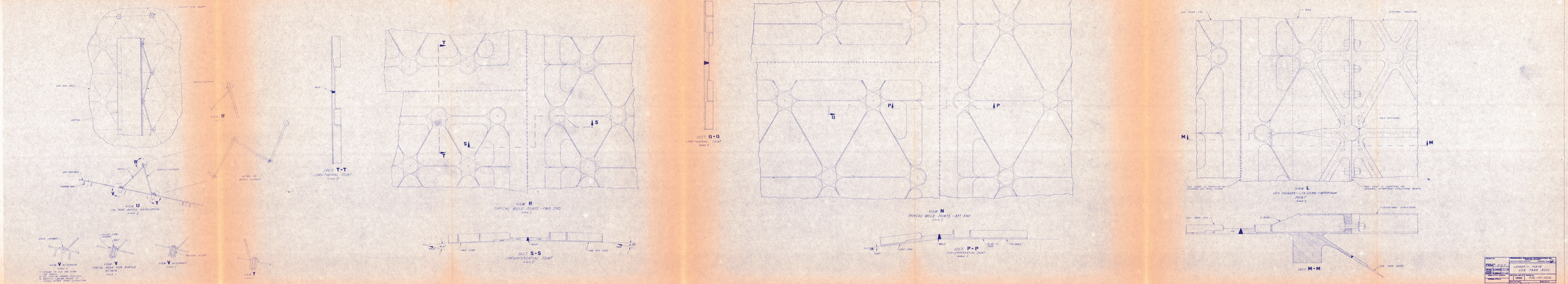
MAIN VIEW
SCALE $\frac{1}{16}$

"X" CHANGE:
1. REVISED NOMINAL WAFFLE GEOMETRY.
2. REDUCED SIZE OF HOLES.
3. REVISED FLAT PATTERN DIMENSION.
4. REVISED VIEW OF 1.90 SUPPORT.
5. MOVED ACCESS DOOR OFF CENTER.

PREVIOUSLY RELEASED AS ECN-19-0012

		LAYOUT – MAIN LOX TANK ASSY.	
13005		ECN-28-0012	

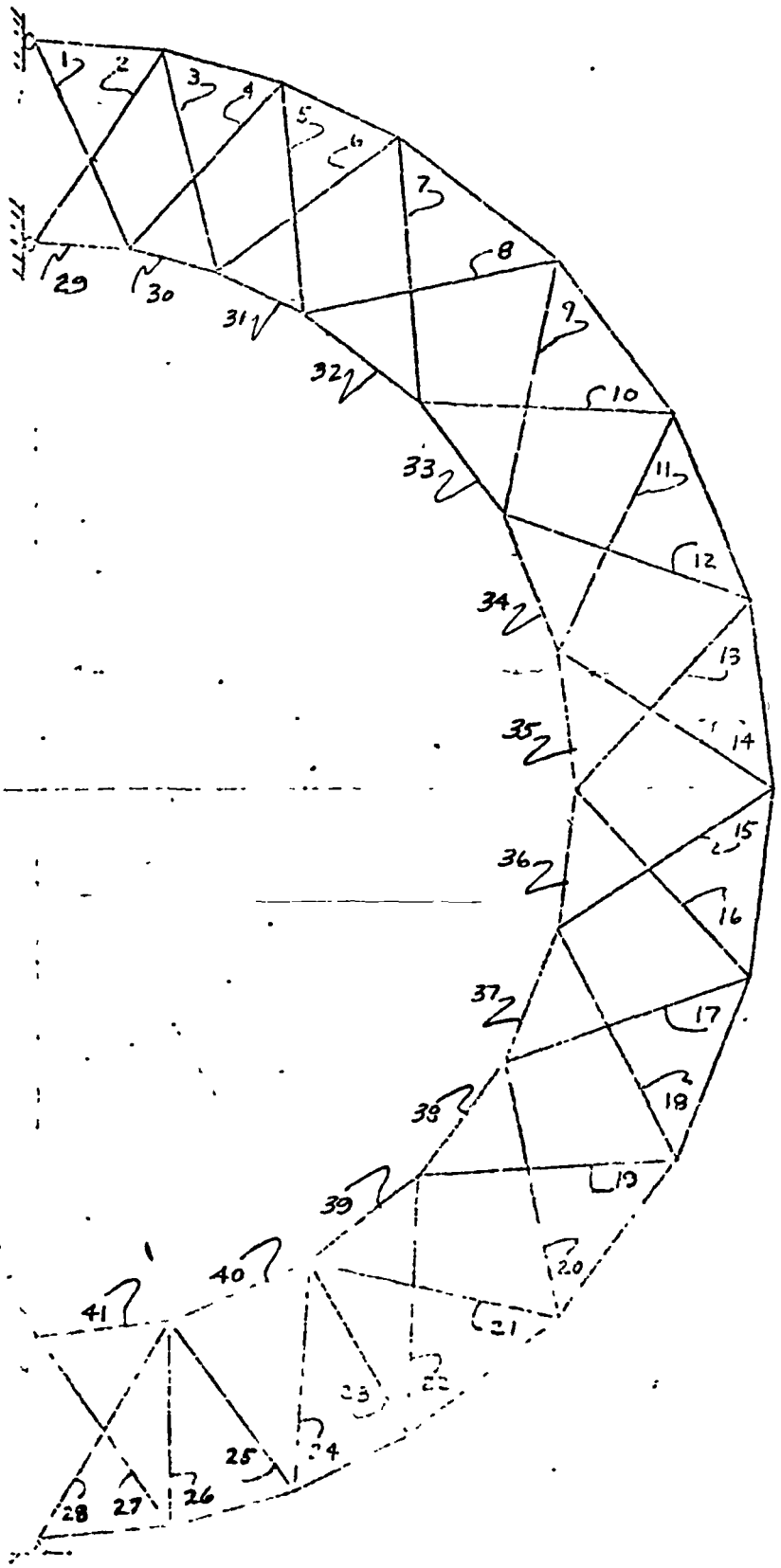
REVISED 11-4-71


VIEW U
LOX TANK BAFFLE INSTALLATION
VIEW V
SPECIAL WEDGE FOR BAFFLE ATTACH
VIEW W
VIEW Y
SECT. T-T
LONGITUDINAL JOINT
VIEW R
TYPICAL WELD JOINTS - FWD END
SECT. S-S
CIRCUMFERENTIAL JOINT
SECT. Q-Q
LONGITUDINAL JOINT
VIEW N
TYPICAL WELD JOINTS - AFT END
SECT. P-P
CIRCUMFERENTIAL JOINT
VIEW L
LOX CYLINDER - LOX DOME - INTERTANK JOINT
SECT. M-M
LAYOUT - MAIN
LOX TANK ASSY.
256-CD-0010

WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
③ BETWEEN TANKS(INTERTANK)		[16717]
FWD FRAME		(2486)
VERTICAL DIAGONALS	62	895
CANTED DIAGONALS	63	548
INNER CAP	64	577
DIAGONAL ENDS - OUTER	66	113
DIAGONAL ENDS - INNER	67	53
AFT FRAME		(1423)
VERTICAL DIAGONALS	70	445
CANTED DIAGONALS	71	[illegible]
INNER CAP	72	373
DIAGONAL ENDS - OUTER	74	[illegible]
DIAGONAL ENDS - INNER	75	[illegible]
ISOGRID JOINT		[illegible]
CIRCUMFERENTIAL JOINTS	77	1332
LONGITUDINAL JOINTS	78	190
SIDEWALL		(10626)
ISOGRID SIDEWALL	79	[illegible]
ORBITER ATTACH BEEF-UP	79	[illegible]
CONTINGENCY = 5%		[illegible]

INTERTANK STRUCTURE - FRAME,



INTERTANK STRUCTURE - FRAME, FWD
VERTICAL DIAGONALS

M*	AREA (IN²)	σ (PSI)	σ_{ALLOW} (PSI)	σ/σ_{ALLOW}	σ/σ_{ALLOW} x A	LENGTH (IN.)	WT. (lb.)	
1	2.25	65,200	50,000	1.304	2.93	57	16.0	
2	2.52	-64,217	↑	1.285	3.24	57	18.4	
3	1.68	—	|	1	1.68	57	9.6	
4	1.68	-51,835	|	1.027	1.72	57	9.8	
5	1.56	75,146	|	1.503	2.35	57	13.4	
6	1.56	—	|	1	1.56	57	8.9	
7	1.50	—	|	1	1.50	65	9.8	
8	1.50	—	|	1	1.50	65	9.8	
9	1.80	—	|	1	1.80	65	11.7	
10	1.80	—	|	1	1.80	65	11.7	
11	2.05	-63,366	|	1.28	2.62	65	17.0	
12	2.05	—	|	1	2.05	65	13.3	
13	2.00	—	|	1	2.00	65	13.0	
14	2.00	66,722	|	1.33	2.66	65	17.3	
15	1.97	-64,654	|	1.32	2.60	65	16.9	
16	1.97	—	|	1	1.97	65	12.8	
17	1.35	—	|	1	1.35	65	8.8	
18	1.35	65440	|	1.305	1.76	65	11.4	
19	2.40	—	|	1	2.40	65	15.6	
20	2.40	-66,003	|	1.32	3.16	65	20.6	
21	4.20	—	|	1	4.20	65	27.3	
22	4.20	—	|	1	4.20	65	27.3	
23	1.90	—	|	1	1.90	50	9.5	
24	5.43	-69,210	|	1.36	7.39	57	42.0	
25	5.53	—	|	1	5.53	53	29.3	
26	1.37	-59,985	|	1.20	1.64	51	8.3	
27	1.87	—	↓	1	1.87	57	10.6	
28	2.32	-75,152	50,000	1.50	4.23	63	26.6	

TOTAL WT. = 447.3 (2 REQ'D)

894.6 lb.

* SEE PAGE 2.3-61 FOR MEMBER NUMBERS

* MEMBER NUMBER

INTERTANK STRUCTURE - FRAME, FWD.
CANTED DIAGONALS

A*	AREA (IN²)	σ (PSI)	σ ALLOW (PSI)	σ/σ ALLOW	σ/σ ALLOW x A	LENGTH** (IN)	WT (lb)	
1	2.25	—	50,000	1	2.25	66	14.9	
2	2.25	—		1	2.25	66	14.9	
3	1.68	—		1	1.68	66	11.1	
4	1.68	—		1	1.68	66	11.1	
5	1.56	—		1	1.56	66	10.3	
6	1.56	—		1	1.56	66	10.3	
7	1.50	—		1	1.50	75	11.2	
8	1.50	—		1	1.50	75	11.2	
9	1.80	—		1	1.80	75	13.5	
10	1.80	—		1	1.80	75	13.5	
11	2.05	—		1	2.05	75	15.4	
12	2.05	—		1	2.05	75	15.4	
13	2.00	—		1	2.00	75	15.0	
14	2.00	—		1	2.00	75	15.0	
15	1.97	—		1	1.97	75	14.8	
16	1.97	—		1	1.97	75	14.8	
17	1.35	—		1	1.35	75	10.1	
18	1.35	—		1	1.35	75	10.1	
19	2.40	—		1	2.40	75	18.0	
20	2.40	—		1	2.40	75	18.0	
21	4.20	—		1	4.20	75	31.5	
22	4.20	—		1	4.20	75	31.5	
23	1.14	—		1	1.14	58	6.6	
24	1.95	-52,712		1.075	2.09	66	13.8	
25	2.38	—		1	2.98	61	18.2	
26	1.27	—		1	1.27	59	7.5	
27	0.90	—		1	0.90	66	5.9	
28	4.90	-54,730	50,000	1.134	5.55	73	40.5	

TOTAL WT. = 424.1 2 REQ.

843.2 lb.

* SEE PAGE 2.3-61 FOR MEMBER NUMBERS

** 67.5 / 59.5 = 1.152 x LENGTH OF VERTICAL DIAGONALS
*MEMBER NUMBER

INTERTANK STRUCTURE – FRAME, FWD
INNER CAP

A*	AREA (IN²)	σ (PSI)	σ_{ALLOW} (PSI)	σ/σ_{ALLOW}	σ/σ_{ALLOW} XA	LENGTH (IN)	WT. (lb)	
29	9.15	–	–	1	9.15	25	22.9	
30	5.25	66,048	65,000	1.016	5.34	25	13.3	
31	5.25	65,635	65,000	1.01	5.30	25	13.2	
32	4.75	68,831	65,000	1.057	5.03	37	18.6	
33	3.85	–	–	1	3.85	37	14.3	
34	4.85	–	–	1	4.85	37	18.0	
35	5.00	–	–	1	5.00	37	18.5	
36	4.35	-94,376	50,000	1.70	7.40	37	27.4	
37	7.15	-65,334	50,000	1.315	9.40	37	34.8	
38	5.85	-66,384	50,000	1.33	7.79	37	28.8	
39	3.00	-59,212	50,000	1.18	4.26	37	15.8	
40	4.60	–	–	1	4.60	41	18.1	
41	12.90	–	–	1	12.90	34	43.9	

TOTAL WT. = 288.4 (2 REQ'D)

576.8 lb.

DIAGONAL ENDS - OUTER

HALF OF OUTER DIAGONAL ENDS WILL BE MAXIMUM STRENGTH, THE OTHER HALF WILL BE MINIMUM STRENGTH

MAX STRENGTH WT = 28 (3.1 LB)[ϕ] = 87
MIN. STRENGTH WT = 28 (0.92 LB)[**] = 26

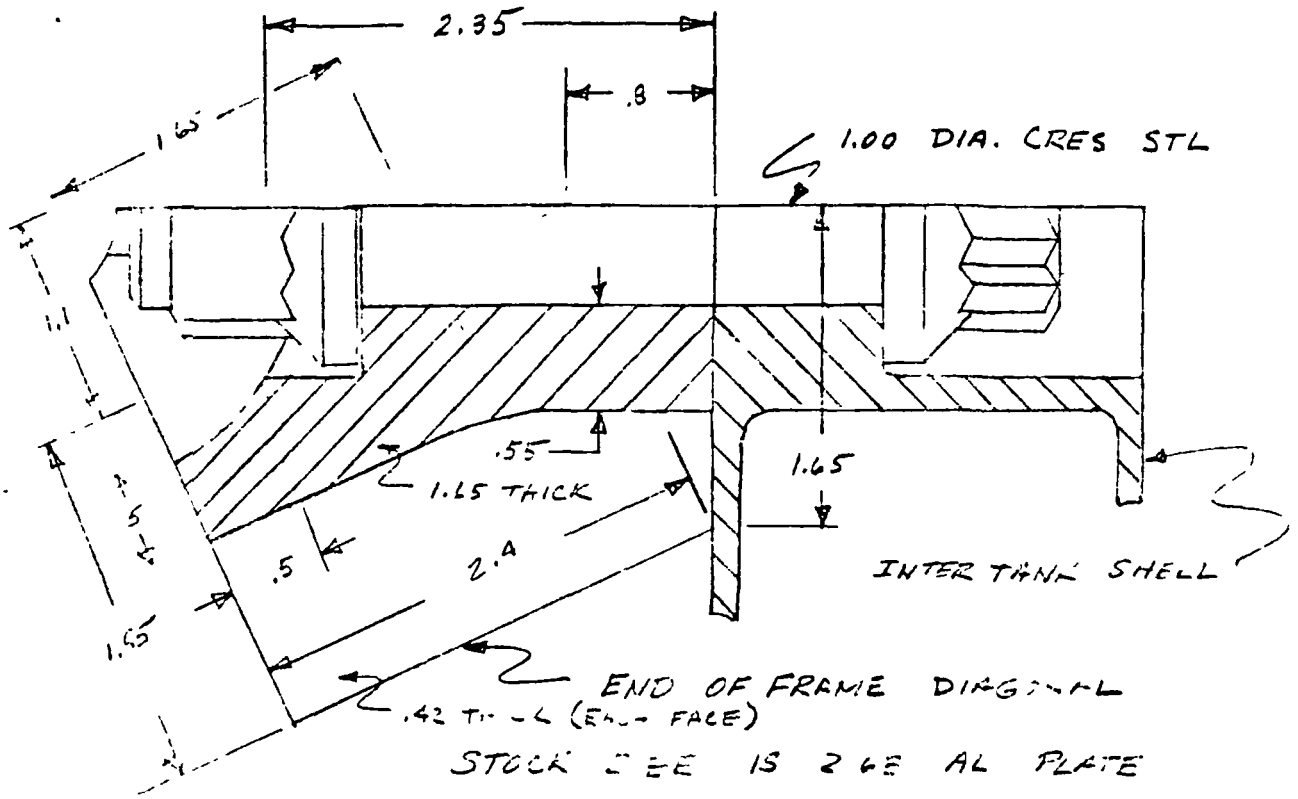
TOTAL WT - OUTER DIAGONAL ENDS = 113 LB

ϕ SEE PAGE 2.3-65

** SEE PAGE 2.3-66

* SEE PAGE 2.3-61 FOR MEMBER ANALYSIS

FRAME TO SHELL JOINT - MAX STRENGTH



STOCK TEE IS 2 GE AL PLATE

$$VOL = 2\left[(2.4 \times 1.35) + (1.1 \times 2.4)/2 + (.3 \times 1.65)/2\right] \times .42 + \left[(.5 \times .5) + (1.15 \times .5)/2 + (2.35 \times 1.05)\right] \times 1.65 - \left[\pi(.5)^2/2\right] 2.35$$

$$= 2\left[4.44 + 1.32 + .66\right] \times .42 + \left[.25 + .293 + 2.47\right] \times 1.65 - .392 \times 2.35$$

$$= 2\left[6.42\right] \times .42 - \left[2.91\right] 1.65 - .392 \times 2.35$$

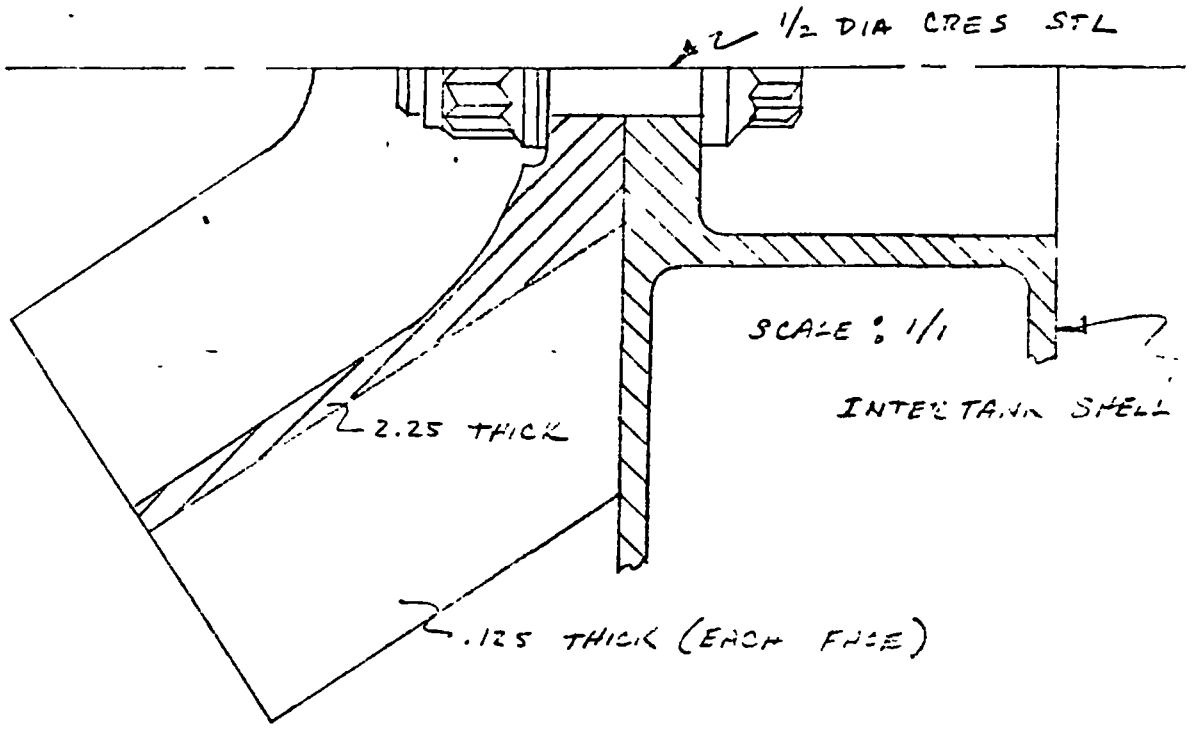
$$= 5.4 + 4.8 - .9 = 9.3 \text{ IN}^3 \quad (2 \text{ REQ})$$

WT = 1.86 PER FRAME END

Bolt = $5.5 \times \pi \times .25 \times .297 =$ 1.24 lb.

TOTAL WT. = 1.86 + 1.24 = 3.1 lb EACH

FRAME TO SHELL JOINT - MIN STRENGTH.



$$VOL = 2\left[(2.2 \times 2.5) + (2.5 \times 1)/2\right] \times .125 + 2.25\left[.15 \times 2 + 1.25 \times .5\right]$$

$$= 2\left[5.5 + 1.25\right] \times .125 + \left[.3 + .68\right] 2.25$$

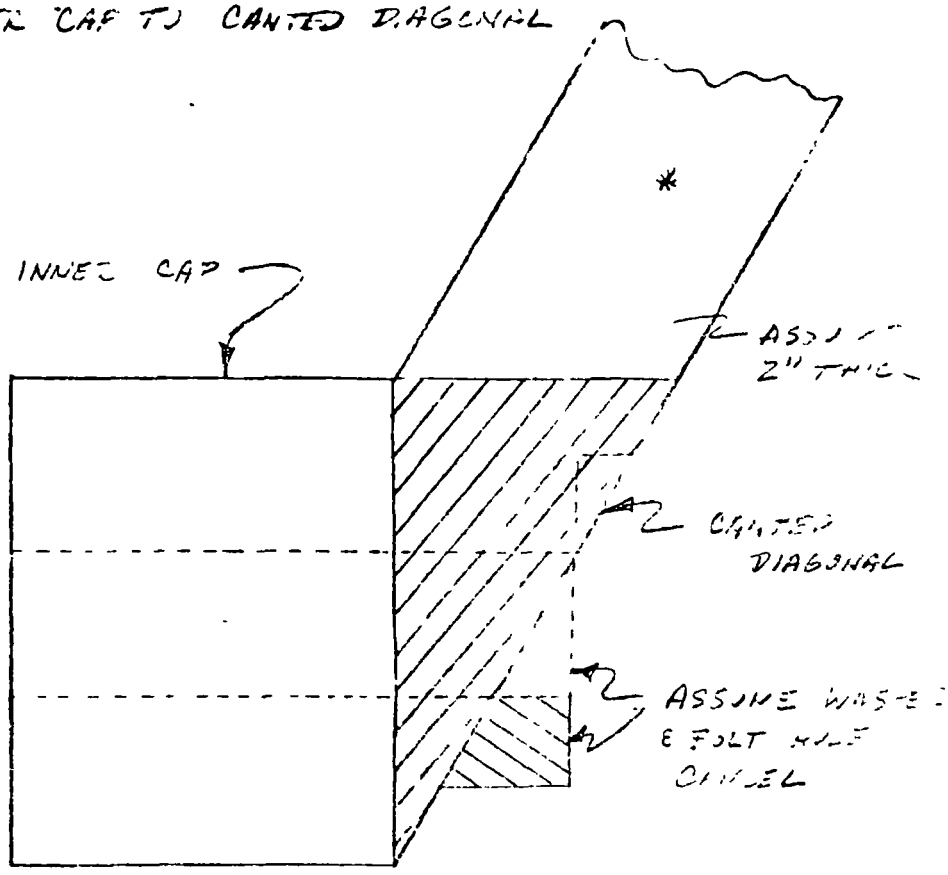
$$= 1.69 + 2.2 = 3.9 \text{ IN}^3 \text{ (2 REQ)}$$

WT = .79 lb. PER FRAME FWD

BOLT = $2.5 \times \pi \times .0625 \times .297 = .141$ lb

TOTAL WT. = .79 + .14 = = <u>.92 lb. EACH</u>

JOINT – INNER CAP TO CANTED DIAGONAL



WT FOR TAPERED END OF CANTED DIAGONAL

$WT. = (.11)[2.5 \times 1.5 \times 2] \times \frac{1}{2} = .275$

$BOLT = .287[\pi \times .375^2 \times 4.5\,IN] = .57\ lb$ EACH

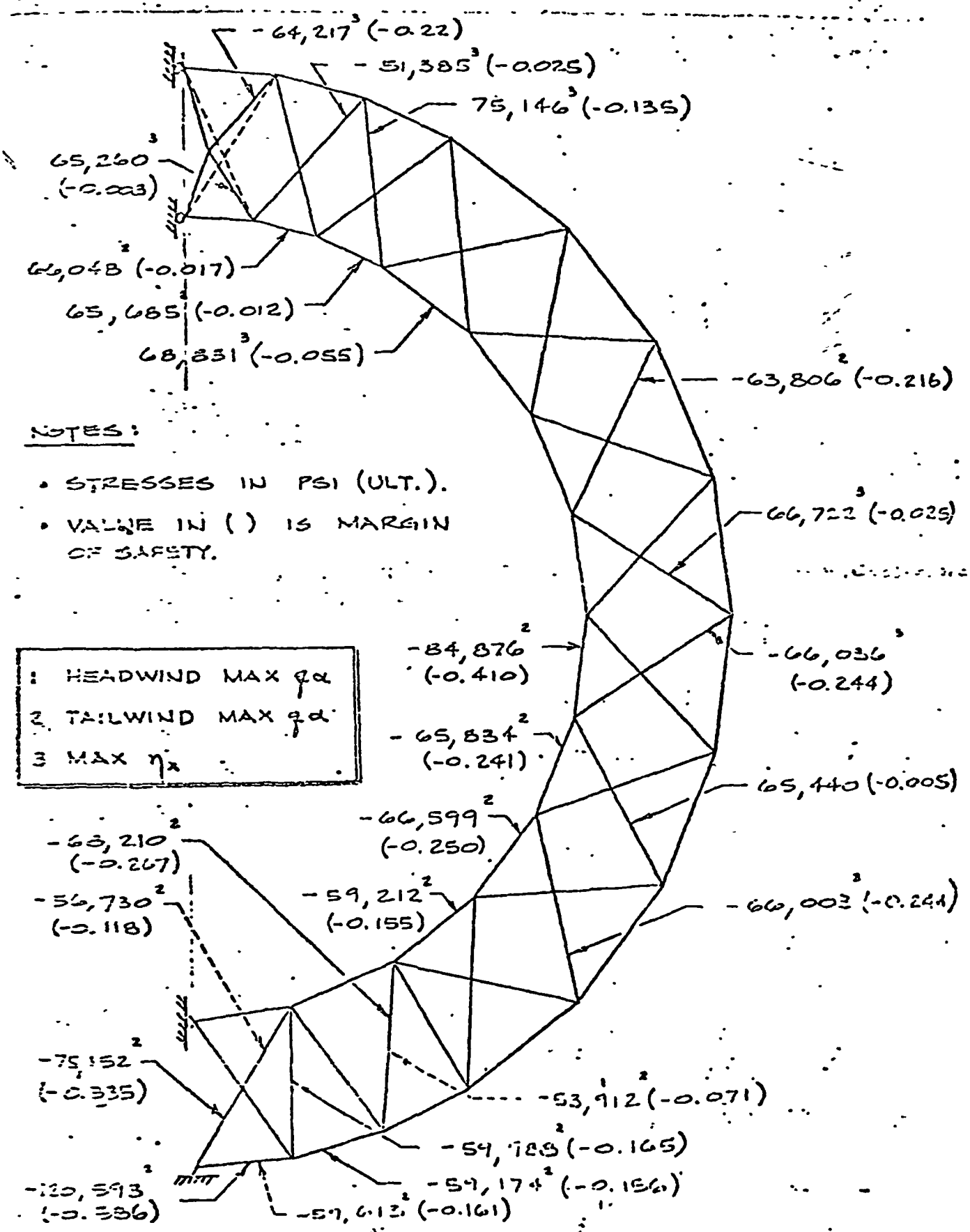
TOTAL = .375 + .57 = .95 lb EACH

56 REQUIRED

TOTAL WT = 56(0 95 LB) = **53 LB**

* THE WT FOR THIS PORTION OF THE CANTED DIAGONAL WAS ACCOUNTED FOR IN THE DIAGONAL WT.

CRITICAL STRESSES - FORWARD INTERTANK FRAME

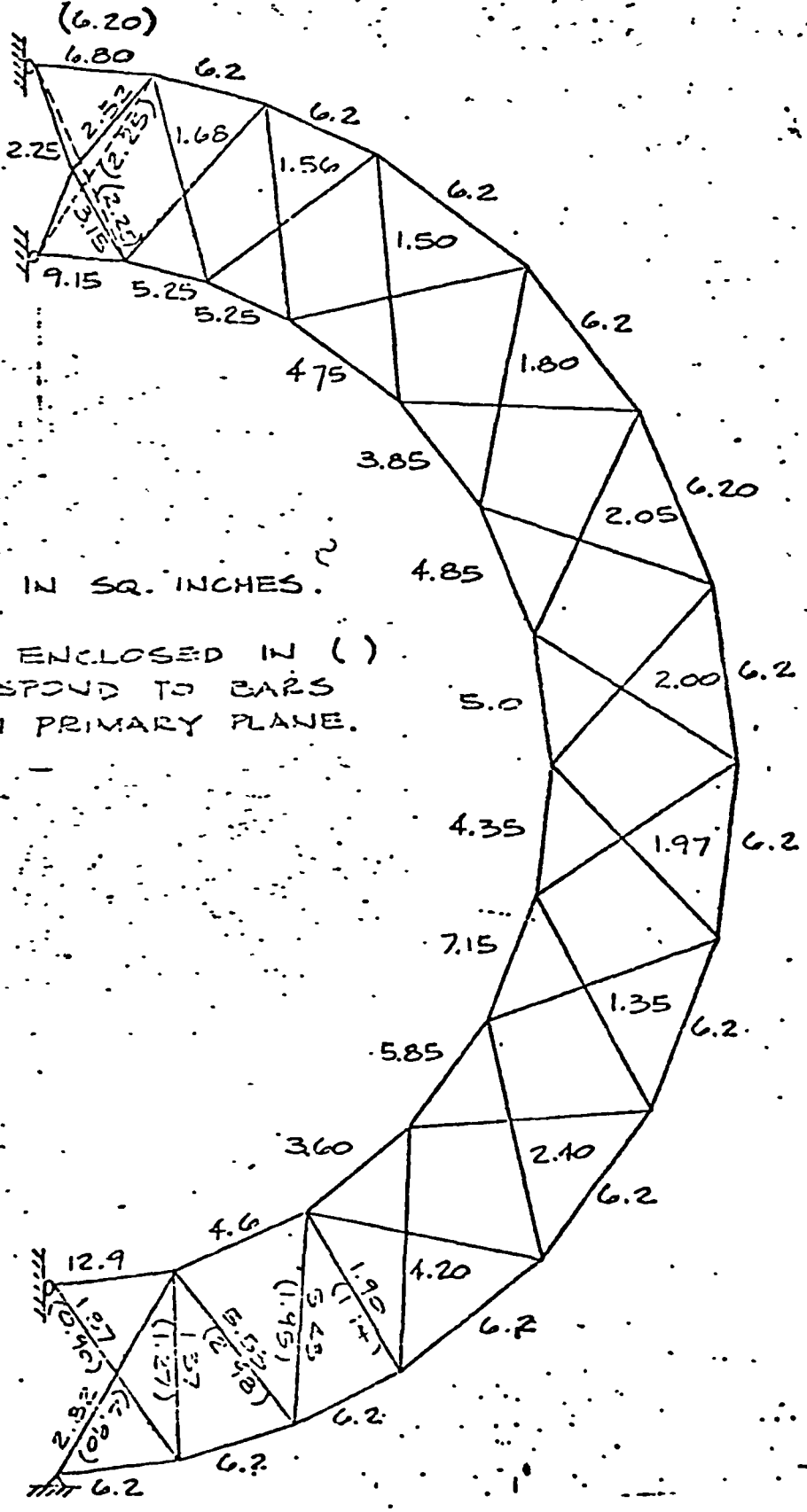


NOTES:

- STRESSES IN PSI (ULT.).
- VALUE IN ( ) IS MARGIN OF SAFETY.

1	HEADWIND MAX $q\alpha$
2	TAILWIND MAX $q\alpha$
3	MAX η_x

BAR AREAS – FORWARD INTERTANK FRAME



NOTES :

1. AREAS IN SQ. INCHES.
2. AREAS ENCLOSED IN ( ) CORRESPOND TO BARS NOT IN PRIMARY PLANE.

INTERTANK STRUCTURE – FRAME, AFT
VERTICAL DIAGONALS

A*	AREA (IN²)	σ (PSI)	σ_{ALLOW} (PSI)	σ/σ_{ALLOW}	σ/σ_{ALLOW} x A	LENGTH (IN)	WT (lb)	
1	1.35	–	–	1	1.35	56	7.6	
2	1.4	-50,010	50,000	1.01	1.42	56	8.0	
3	0.9	–	–	1	0.9	56	5.0	
4	0.9	–	–	1	0.9	56	5.0	
5	0.9	–	–	1	0.9	56	5.0	
6	0.9	–	–	1	0.9	56	5.0	
7	0.9	–	–	1	0.9	65	5.9	
8	0.9	-51,220	50,000	1.02	0.92	65	6.0	
9	0.9	–	–	1	0.9	65	5.9	
10	0.9	–	–	1	0.9	65	5.9	
11	0.9	–	–	1	0.9	65	5.9	
12	0.9	–	–	1	0.9	65	5.9	
13	0.9	–	–	1	0.9	65	5.9	
14	0.9	–	–	1	0.9	65	5.9	
15	0.9	-58,442	50,000	1.17	1.05	65	6.8	
16	0.9	–	–	1	0.9	65	5.9	
17	0.9	–	–	1	0.9	65	5.9	
18	0.9	–	–	1	0.9	65	5.9	
19	0.9	–	–	1	0.9	65	5.9	
20	0.9	–	–	1	0.9	65	5.9	
21	0.9	–	–	1	0.9	65	5.9	
22	0.9	–	–	1	0.9	65	5.9	
23	1.50	–	–	1	1.50	52	7.8	
24	3.90	–	–	1	3.90	60	23.4	
25	2.65	76,934	50,000	1.54	4.07	55	22.4	
26	1.92	–	–	1	1.92	53	10.2	
27	2.25	–	–	1	2.25	58	13.0	
28	2.25	–	–	1	2.25	65	14.6	

TOTAL WT. = 222.4 (2 REQ'D)

444.8 lb

SEE PAGE 2.3-61 FOR MEMBER NUMBERS

* MEMBER NUMBER

INTERTANK STRUCTURE - FRAME, AFT
CANTED DIAGONALS

A*	AREA (IN²)	σ (PSI)	σ_{ALLOW} (PSI)	σ/σ_{ALLOW}	$\sigma/\sigma_{ALLOW} \times A$	LENGTH** (IN)	WT. (lb)	
1	0.9	—	50,000	1	.9	65	5.9	
2	0.9	—		1	.9	65	5.9	
3	0.9	—		1	.9	65	5.9	
4	0.9	—		1	.9	65	5.9	
5	0.9	—		1	.9	65	5.9	
6	0.9	—		1	.9	65	5.9	
7	0.9	—		1	.9	75	6.8	
8	0.9	—		1	.9	75	6.8	
9	0.9	—		1	.9	75	6.8	
10	.9	—		1	.9	75	6.8	
11	.9	—		1	.9	75	6.8	
12	.9	—		1	.9	75	6.8	
13	.9	—		1	.9	75	6.8	
14	.9	—		1	.9	75	6.8	
15	.9	—		1	.9	75	6.8	
16	.9	—		1	.9	75	6.8	
17	.9	—		1	.9	75	6.8	
18	.9	—		1	.9	75	6.8	
19	.9	—		1	.9	75	6.8	
20	.9	—		1	.9	75	6.8	
21	.9	—		1	.9	75	6.8	
22	.9	—		1	.9	75	6.8	
23	1.50	—		1	1.50	60	9.0	
24	1.50	—		1	1.50	69	10.3	
25	1.92	—		1	1.92	63	12.1	
26	1.92	—		1	1.92	61	11.7	
27	2.25	—		1	2.25	67	15.1	
28	2.25	—	50,000	1	2.25	75	16.9	

TOTAL WT. = 219.5 (2 REQ.)

$\boxed{438.6 \text{ LB}}$

X SEE PAGE 2.3-[illegible] FOR MEMBER NUMBERS

** 67.5/58.5 = 1.152 X LENGTH OF VERTICAL DIAGONALS
* MEMBER NUMBER

INTERTANK STRUCTURE – FRAME, AFT
INNER CAP

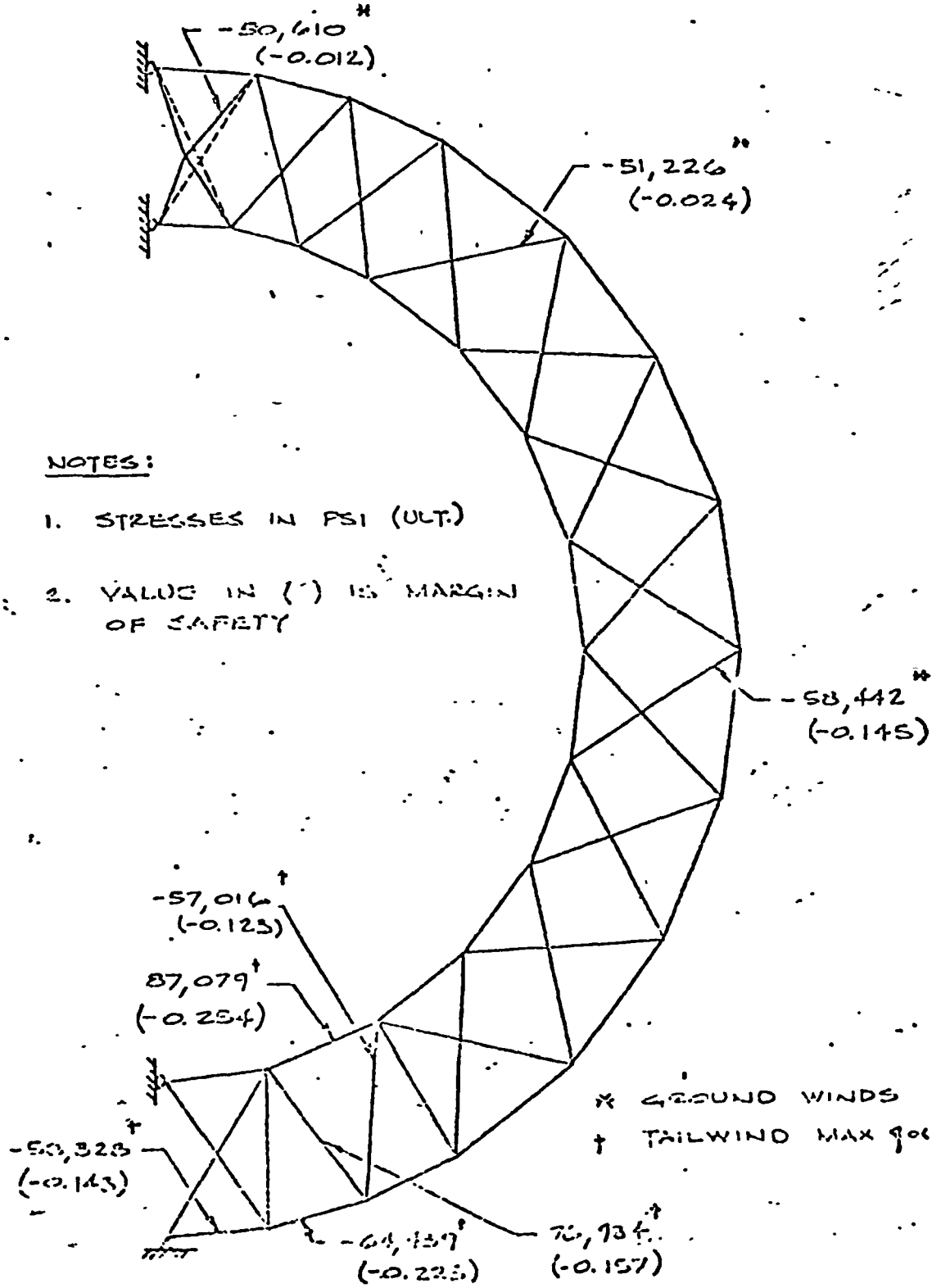
A*	AREA (IN²)	σ (PSI)	σ_{ALLOW} (PSI)	σ/σ_{ALLOW}	σ/σ_{ALLOW} X A	LENGTH (IN)	WT. (lb)	
29	3.91	–	–	1	3.91	25	9.3	
30	3.72	–	–	1	3.72	25	9.3	
31	3.23	–	–	1	3.23	25	8.2	
32	2.54	–	–	1	2.54	37	9.4	
33	1.75	–	–	1	1.75	37	6.5	
34	1.75	–	–	1	1.75	37	6.5	
35	3.76	–	–	1	3.76	37	13.9	
36	5.64	–	–	1	5.64	37	20.9	
37	6.50	–	–	1	6.50	37	24.1	
38	6.30	–	–	1	6.30	37	23.4	
39	4.93	–	–	1	4.93	37	18.4	
40	2.39	–	–	1	2.39	41	9.8	
41	7.75	–	–	1	7.75	34	26.4	

TOTAL WT.= 186.6 (2 REQ.)

373.2 lb.

* SEE PAGE 2.3-31 FOR MEMBER LOCATIONS

CRITICAL STRESSES – AFT INTERCARK BRACE

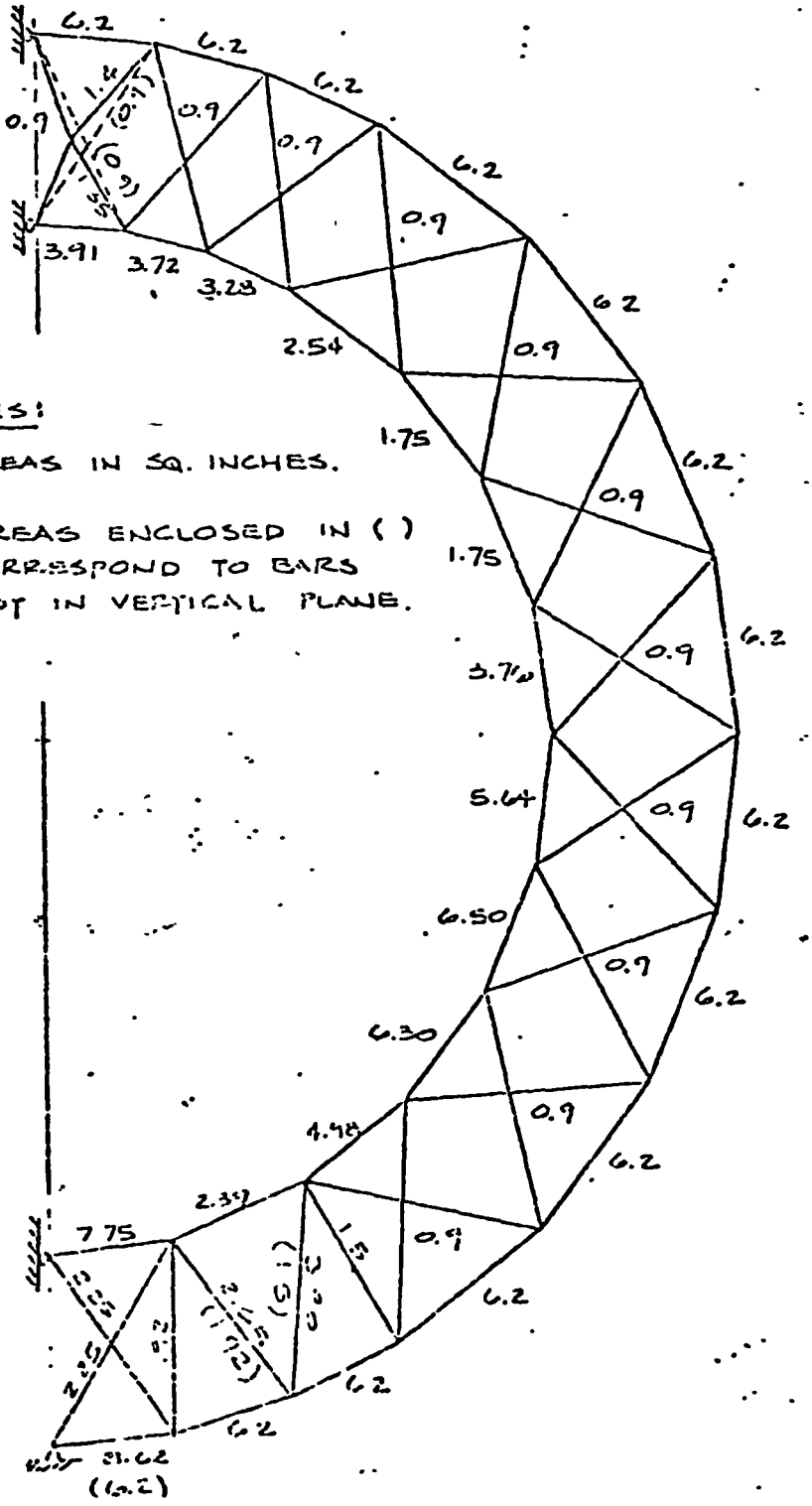


NOTES:

1. STRESSES IN PSI (ULT.)
2. VALUE IN (-) IS MARGIN OF SAFETY

* GROUND WINDS
† TAILWIND MAX q

BAR AREAS – AFT INTERTANK FRAME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6.2
6.2
6.2
6.2
0.9
0.9
0.9
0.9
0.9
0.9
0.9
0.9
0.9
0.9
0.9
0.9
0.9
0.9
3.91
3.72
3.28
2.54
1.75
1.75
3.70
5.64
6.50
6.30
4.98
2.39
7.75
(0.9)
(0.9)
(0.9)

INTERTANK STRUCTURE - SHELL JOINT PENALTY

SUMMARY

CIRCUM'L JOINT

SEE PAGE 2.3-76

ISOGRID PENALTY (.066 lb/in PER SIDE)	.132
FASTENERS (SEE PAGE 2.3-77)	.061
	.193 lb/in*

LONGITUDINAL JOINT

SEE PAGE 2.3-77

ISOGRID PENALTY (.03 lb/in PER SIDE)	.060
FASTENERS (SEE PAGE 2.3-77)	.053
	.113 lb/in*

SUMMARY (SEE PAGE 2.3-78 FOR JOINT LENGTHS

	lb/in	in	lb.
CIRCUM'L	.193	7220	1372 LB
LONG'T'L	.113	1680	190 LB

AROUND LANDING GEAR DOOR

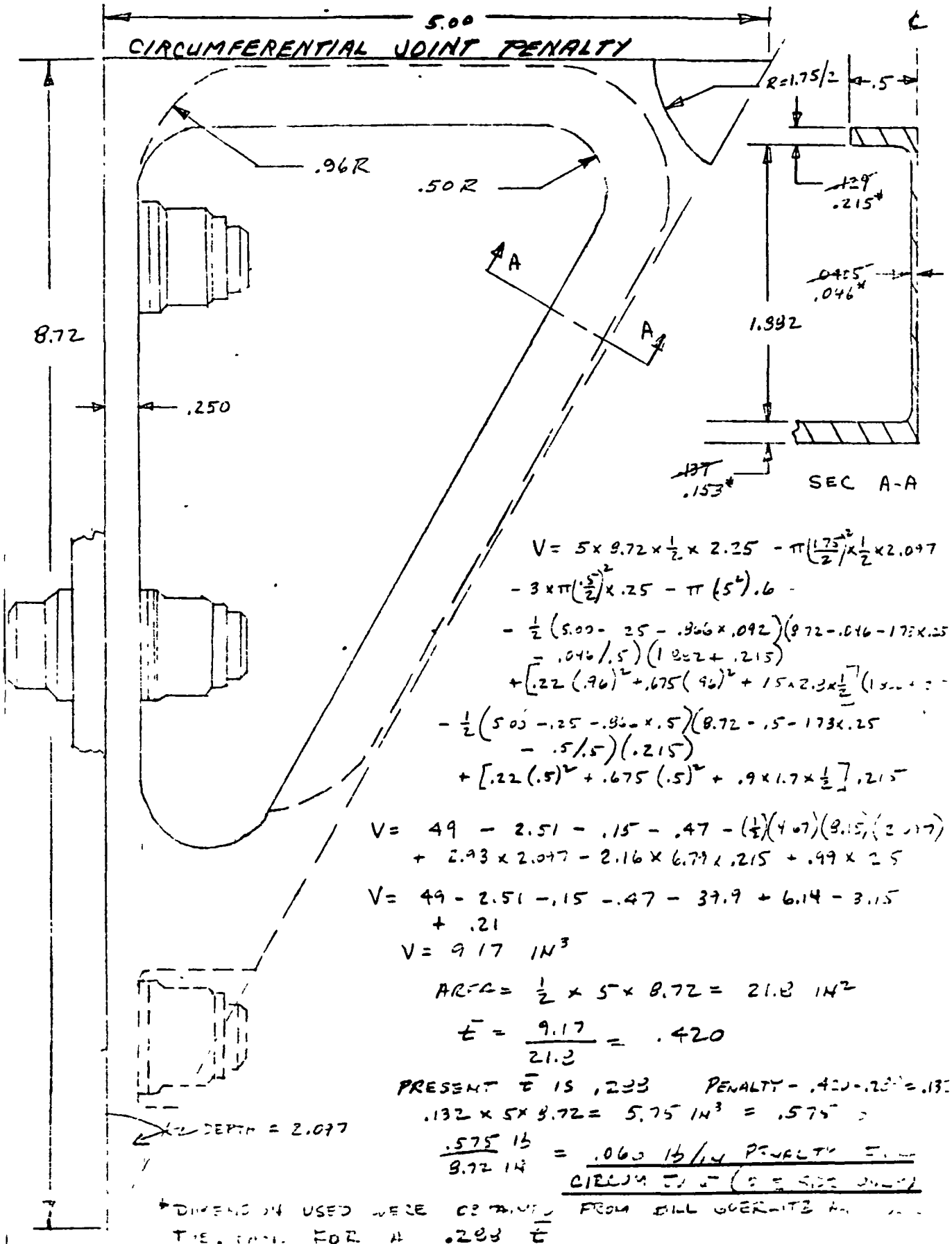
ASSUME NO JOINT BUT ASSUME ISOGRID TERMINATION LIKE CIRCUM'L JOINT.

	lb/in	in	lb.
DOOR OPENING	.132	548***	72 lb**

** INCLUDED IN NOSE GEAR DOOR PROVISIONS AS JAMB

*** SEE PAGE 2.3-78 FOR JAMB PERIPHERY

* REPRESENTS PENALTY FOR TOTAL JOINT (BOT. SHELL)



$$V = 5 \times 8.72 \times \tfrac{1}{2} \times 2.25 - \pi\left(\tfrac{1.75}{2}\right)^2 \times \tfrac{1}{2} \times 2.097$$
$$- 3 \times \pi\left(\tfrac{.5}{2}\right)^2 \times .25 - \pi\,(.5^2)\,.6$$
$$- \tfrac{1}{2}\left(5.00 - .25 - .866 \times .092\right)\left(8.72 - .046 - 1.73 \times .25 - .046/.5\right)\left(1.882 + .215\right)$$
$$+ \left[.22\,(.96)^2 + .675\,(.96)^2 + 1.5 \times 2.3 \times \tfrac{1}{2}\right](1.882 + \ldots$$
$$- \tfrac{1}{2}\left(5.00 - .25 - .866 \times .5\right)\left(8.72 - .5 - 1.73 \times .25 - .5/.5\right)\left(.215\right)$$
$$+ \left[.22\,(.5)^2 + .675\,(.5)^2 + .9 \times 1.7 \times \tfrac{1}{2}\right].215$$

$$V = 49 - 2.51 - .15 - .47 - \left(\tfrac{1}{2}\right)(4.67)(8.15)(2.097)$$
$$+ 2.93 \times 2.097 - 2.16 \times 6.79 \times .215 + .99 \times .25$$

$$V = 49 - 2.51 - .15 - .47 - 39.9 + 6.14 - 3.15 + .21$$

$$V = 9.17 \text{ IN}^3$$

$$\text{AREA} = \tfrac{1}{2} \times 5 \times 8.72 = 21.8 \text{ IN}^2$$

$$\bar{t} = \frac{9.17}{21.8} = .420$$

PRESENT $\bar{t}$ IS .288 PENALTY – .420 – .288 = .132

$$.132 \times 5 \times 8.72 = 5.75 \text{ IN}^3 = .575 \text{ lb}$$

$$\frac{.575 \text{ lb}}{8.72 \text{ IN}} = .066 \text{ lb/in PENALTY FOR CIRCUM JOINT (ONE SIDE ONLY)}$$

*DIMENSION USED WERE OBTAINED FROM BILL GOERLITZ AND ... THE ... FOR A .288 $\bar{t}$

LONGITUDINAL JOINT PENALTY

THIS PENALTY IS ONLY A THICKER RIB ALONG ONE SIDE OF THE 150621D POCKET – .250 VS. .097 OR .163 THICK TIMES THE HEIGHT BETWEEN CAP & WEB – 1.992 TIMES THE LENGTH WHICH IS NEARLY 10 IN. OR ≈ 9.8 IN.

$V = .163 \times 1.992 \times 9.8 = 3\ IN^3$

WT = .3 lb OR .03 lb/IN OF JOINT

THIS .03 lb/IN REPRESENTS ONLY ONE SIDE OF JOINT

FASTENERS AT JOINTS	WT. (lb).
EWB0420-9-9 BOLT	.131
61170-920 NUT	.044
AN960D916 WASHER	.00249
	.17749 lb

LONGITUDINAL JOINT

3 FASTENERS PER 10 IN.

3 × .17749 = .5324 lb/10"

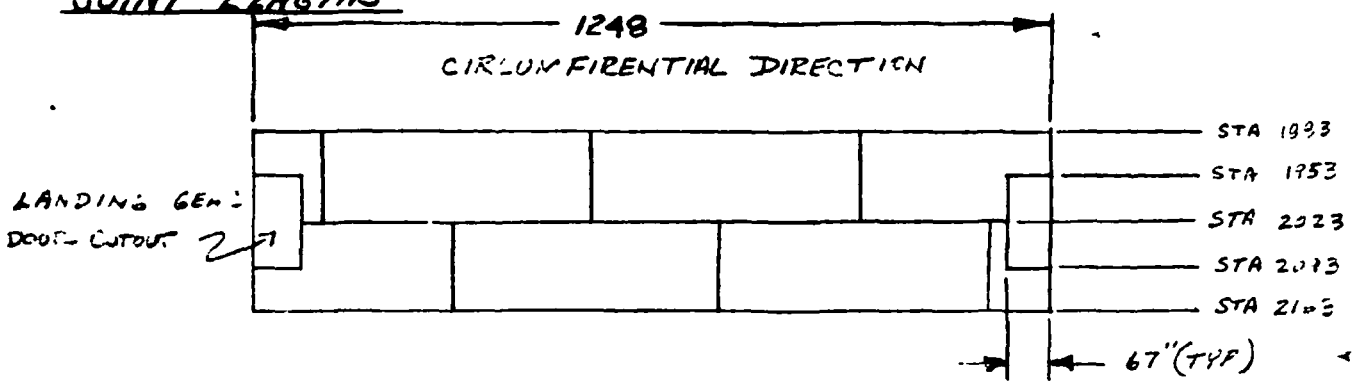
OR .053 lb/IN

CIRCUM'L JOINT

3 FASTENERS PER 9.72 IN

OR $\frac{.5324}{9.72} = .061$ lb/IN.

JOINT LENGTHS



CIRCUMFIRENTIAL JOINTS

STA.	JOINT LENGTH	TYPE JOINT	
1993	1249	DOUBLE	2498
2023	1114	"	2229
2163	1248	"	2496
			7220 IN TOTAL

LONGITUDINAL JOINTS

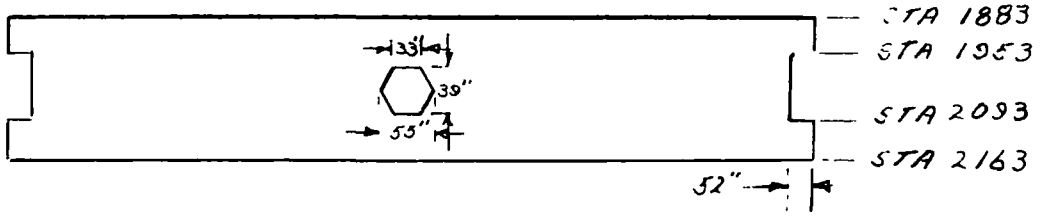
6 DOUBLE JOINTS 140" LONG 1680 IN TOTAL

LANDING GEAR DOOR PERIPHERY

$2[67 \times 2 + 140] = 2[134 + 140] = 548"$

WEIGHT SUBSTANTIATION

ISOGRID SIDEWALL



$$\text{AREA} = 1248(2163-1883) - 2(52)(2093-1953) - 39\left(\frac{55+33}{2}\right)$$
$$= 1248(280) - 104(140) - 39(44) - 39(44)$$
$$= 349{,}440 - 14560 - 1715 = 333{,}165 \text{ IN}^2$$

USING A $\bar{E}$ OF 0.287 (SEE NEXT PAGE) AND ADDING A 7% NODAL PENALTY

$$WT = 1.07(333{,}165)(0.287)(.1) = \boxed{10{,}240 \text{ LB}}$$

ORBITER ATTACH BEEF-UP

THE HEXACON AREA IN THE ISOGRID SIDEWALL IS INCREASED TO 2.25" THICK

$$WT = 1{,}715(2.25)(.1) = \boxed{386 \text{ LB}}$$

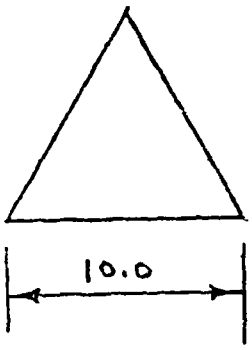
INTERTANK BETWEEN LOX AND LH_2 TANKS

STA, 1883 – 2163

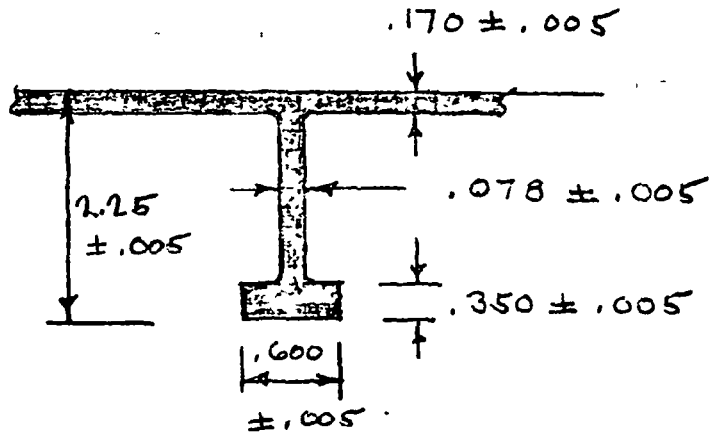
DUE TO THE ORBITER FWD. CONN. DETAIL, IT IS ASSUMED THAT THE MAX. LOADED TANK PANELS HAVE THE MAX. N_c BETWEEN STA. 1883-2163 FROM THE COMPRESSIVE LOAD ENVELOPE,

$N_{cr} = 11\,345$ LB./IN.

$\therefore \epsilon = 0.287$ in.

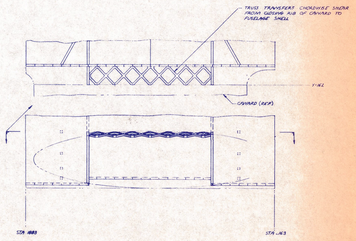


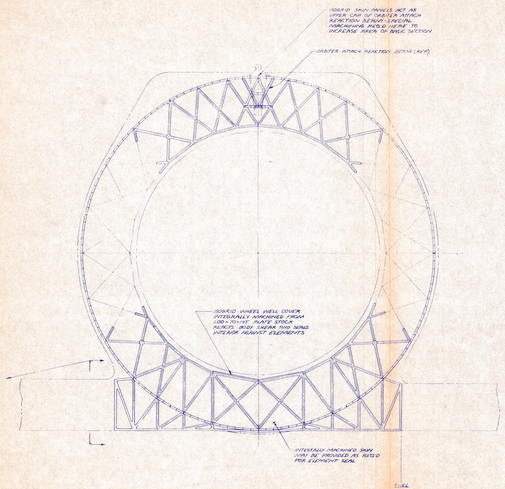
GRID SIZE

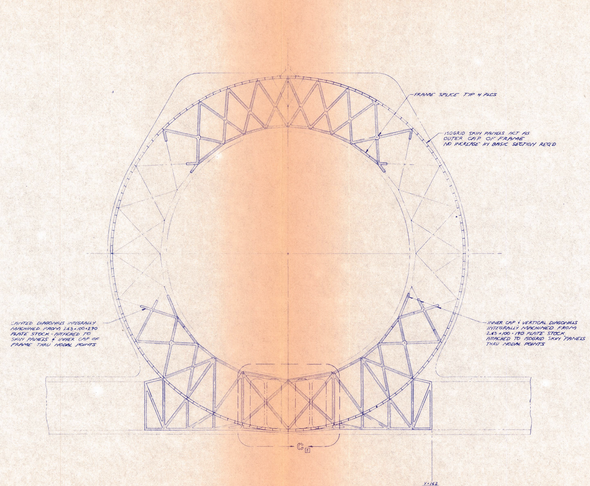


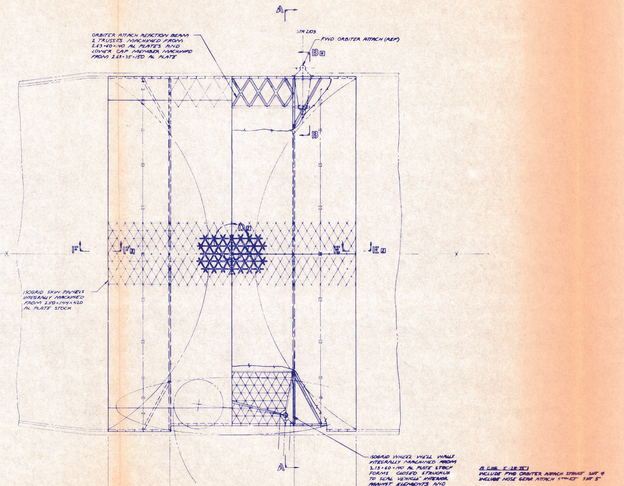
RIB DETAIL

NOMINAL DIMENSIONS



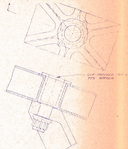


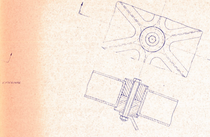


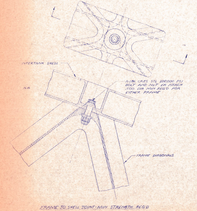


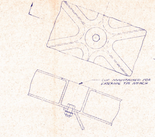
PREVIOUSLY REVISED PER 338-4F-0006

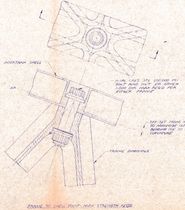
		LAYOUT-INTERTANK STRUCTURE	
		338-10-0007	

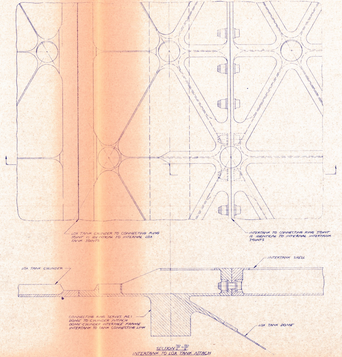


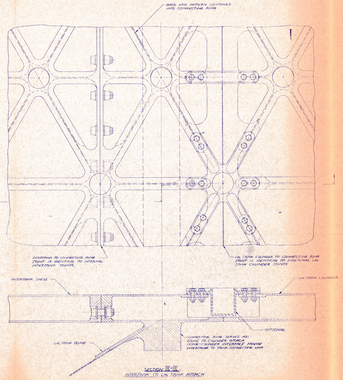


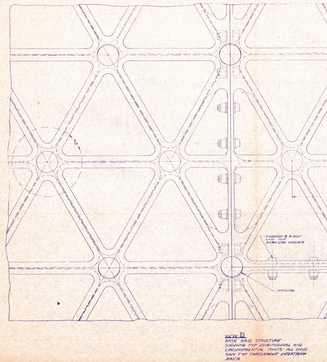


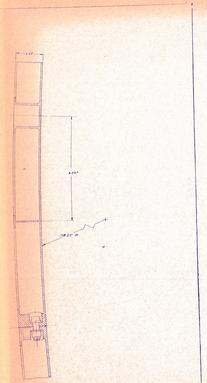


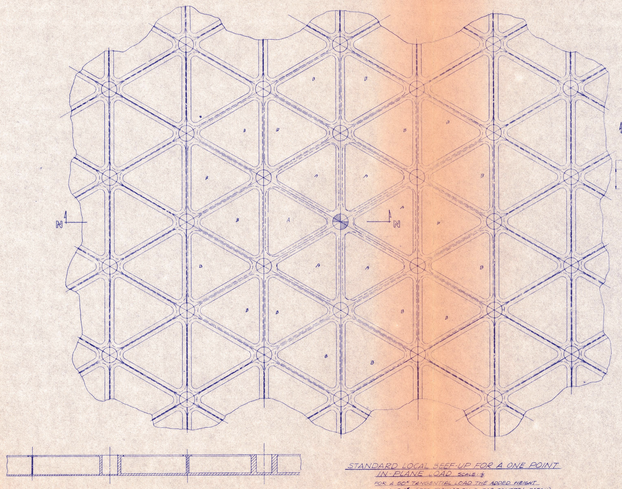






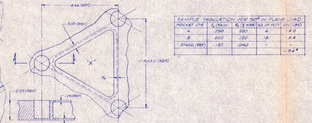






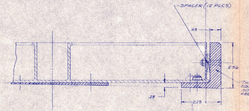
SECTION M-M

STANDARD LOCAL BEEF-UP FOR A ONE POINT IN PLANE LOAD SCALE: 1/2
FOR A 90° TANGENTIAL LOAD THE ADDED WEIGHT IS 9.8# (SEE FABRICATION & FAB CONTROL DETAIL)

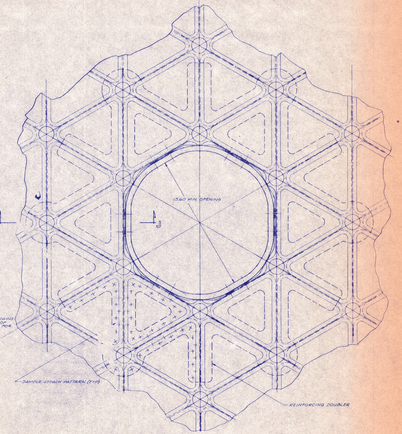


STANDARD FABRICATION CONTROLS
(SOME DIMENSIONS TOLERANCES ARE HELD TO MINIMUM DIMENSIONS BUT PANELS ARE BASED ON MAXIMUM WEIGHT CONTROLS

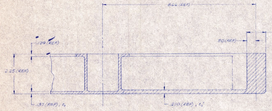
SAMPLE FABRICATION FOR 90° IN PLANE LOAD				
POCKET OR	t_1 (OHM)	t_2 (OHM)	NO. OF PLATES	NO. LOADS
A	.250	.100	4	4.8
B	.200	.150	4	5.4
STAND. (FEET)	.157	.040	-	-
				9.8#



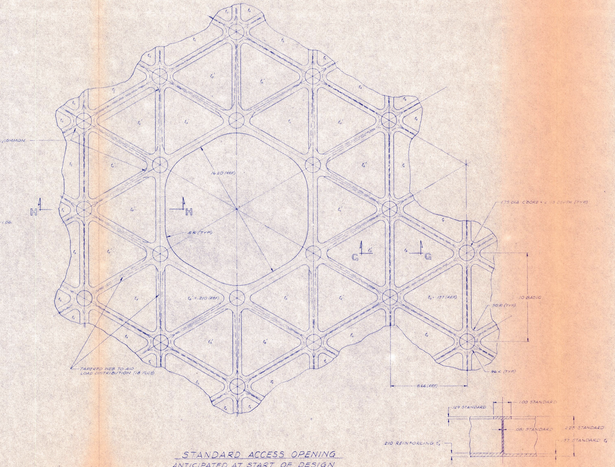
SECTION J-J



STANDARD ACCESS OPENING SCALE: 1/2
REWORKED AFTER SHELL FABRICATION USING INTEGRALLY MACHINED DOUBLER
(NOT ANTICIPATED IN ORIGINAL DESIGN)



SECTION H-H



STANDARD ACCESS OPENING
ANTICIPATED AT START OF DESIGN
SCALE: 1/2

SECTION G-G

INTERTANK STRUCT.
(ACCESS OPENING)

WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
④ INSULATION - FUEL TANK		[4113]
FUEL TANK-INTERNAL INSUL.		(4113)
LINER	84	971
FOAM	84	1785
BOND	84 (THIS PAGE)	1357

INSULATION - LH_2 TANK

$$AREA = \pi DL + 2[2\pi RH]$$

CYLINDER DOMES

$$= \pi(33)(115.8) + 4\pi(19.1)9.5$$

$$= 12{,}000 + 2{,}275 = 14{,}275\ FT^2$$

LINER

R-B COAT
RESIN
116 CLOTH

$= 0.068\ LB/FT^2 \times 14{,}275 = 971$

3D FOAM

1/2" THICK @ $3\ LB/FT^3 = 0.125\ LB/FT^2 \times 14{,}275 = 1{,}785$

BOND

LEFKOWELD @ $0.095\ LB/FT^2 \times 14{,}275 = 1{,}357$

TOTAL INSULATION WEIGHT **4,113 LB**

WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
⑤ NOSE SECTION SHELL	85 (THIS PAGE)	[967]

NOSE SECTION SHELL

SUREACE AREA - UNCUT

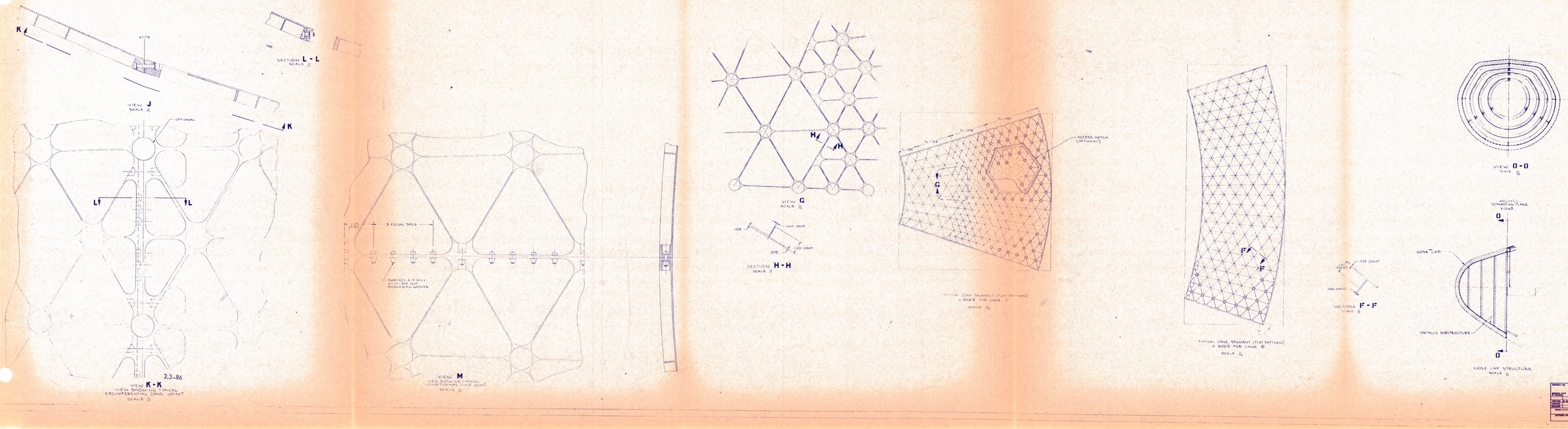
STA	RADIUS IN.	PERIPHERY FT	AVERAGE PERIPHERY × LENGTH
1039	19	9.9	
1080	45	23.5	16.7 (3.42) =
1110	59	30.9	27.2 (2.50) =
1140	71	37.1	34.0 (2.50) =
1180	86	45.0	41.0 (3.33) =
1235	104	54.4	49.7 (4.58) =
NOSE CAP	3.14(2)(.78) =		6.3 (0.78) =

} = 579 FT²

WEIGHT (DCB NOSE STR - UNCUT) = 1.67 LB/FT²

ESTIMATED WEIGHT OF BOOSTER NOSE STRUCTURE

WEIGHT = 579 (1.67) = **967 LB**


K
K
VIEW J
SCALE 1/1
SECTION L - L
SCALE 1/1
OPTIONAL
L
L
2.3-86
VIEW K - K
VIEW SHOWING TYPICAL CIRCUMFERENTIAL CONE JOINT
SCALE 1/1
3 EQUAL SPCS
VIEW M
VIEW SHOWING TYPICAL LONGITUDINAL CONE JOINT
SCALE 1/1
H
H
VIEW G
SCALE 1/2
.060 CONST
1.00 CONST
.075
SECTION H - H
SCALE 1/1
ACCESS HATCH (OPTIONAL)
G
TYPICAL CONE SEGMENT (FLAT PATTERN)
2 REQ'D FOR CONE ⓐ
SCALE 1/10
F
F
TYPICAL CONE SEGMENT (FLAT PATTERN)
3 REQ'D FOR CONE ⓑ
SCALE 1/10
.093 CONST
.060 CONST
SECTION F - F
SCALE 1/1
VIEW O - O
SCALE 1/10
ASSUMED SEPARATION PLANE
X10.5
O
NOSE CAP
METALLIC SUBSTRUCTURE
O
NOSE CAP STRUCTURE
SCALE 1/10
REVISION 'A' 2-12-71
NOSE SECTION, BOOSTER
J
18355
256-20-0015

WEIGHT SUBSTANTIATION

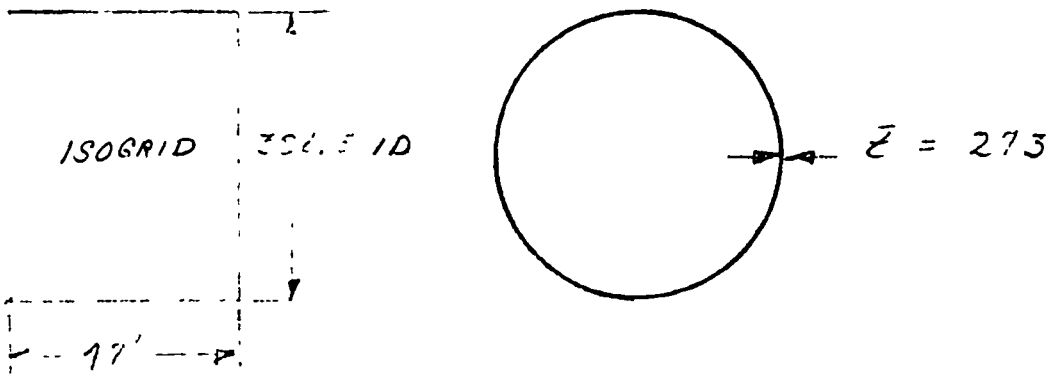
ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
⑥ THRUST STRUCTURE		[37797]
SIDEWALL-STA 3553-3600		(2148)
ISOGRID SIDEWALL	85	1733
CIRCUMFERENTIAL JOINTS	85	399
LONGITUDINAL JOINTS	89	16
SIDEWALL-STA 3604-3710		(4244)
ISOGRID SIDEWALL	90 & 91	3820
CIRCUMFERENTIAL JOINTS	90 & 91	382
LONGITUDINAL JOINTS	91	42
SIDEWALL-STA 3714-3788		(2891)
ISOGRID SIDEWALL	92 & 93	2596
CIRCUMFERENTIAL JOINTS	92 & 93	266
LONGITUDINAL JOINTS	92 & 93	29
FRAME - STA 3600	95 TO 101	(2686)
CAP	95	1816
WEB	97	774
BRACES	113 TO 116	96
FRAME - STA 3710	102 TO 107	(3722)
CAP	102	2410
WEB	105	1250
BRACES	113 TO 116	62
FRAME - STA 3792	108 TO 112	(4560)
CAP	108	2957
WEB	110	1538
BRACES	113 TO 116	65
INBOARD BEAMS AND WEB	117 TO 121	(8660)
BEAMS	118	3643
CENTER WEB	119 & 120	3040
VERTICAL OUTBOARD WEB	121	1977

WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
⑥ THRUST STRUCTURE-CONTINUED		
LAUNCH LOAD FITTINGS		(3000)
UPPER LAUNCH FITTINGS	122 & 123	1580
LOWER LAUNCH FITTINGS	124 & 125	692
LOAD DISTRIBUTION LONGERONS	126	728
STIFFENERS AND FITTINGS		(2544)
ACTUATOR LOAD STIFFENERS	127	613
ENGINE LOAD STIFFENERS	127	922
ENGINE MOUNTING FITTINGS	127	835
ACTUATOR ATTACH FITTINGS	128	149
HEAT SHIELD ATTACH FITTINGS	128	25
BOAT TAIL		(4358)
SUPPORT TRUSS	129 & 130	851
EXTERIOR ISOGRID PANELS	131 & 134	2999
TRUSS SUPPORT STRUTS	135 & 136	160
TRUSS SUPPORT BEAMS	137 & 138	248
BASE HEAT PANEL STAND-OFF	139	100
REDESIGN OF THRUST STRUCTURE	144 TO 158	(-1016)

THRUST STRUCTURE SIDEWALL

STA 356 – 3600



$A_{AVG} = \pi(356.5)(.7) = 58{,}600\ IN^2$

CIRCUMFERENTIAL JOINTS

LENGTH = π 398.7 = 1,245" OF HALF JOINT
LENGTH = π 398.7 = 1,245" OF TOTAL JOINT *

LONGITUDINAL JOINTS

LENGTH = 3 (47) = 141" OF TOTAL JOINT

WEIGHT

SIDEWALL WT$^{\phi}$ = 58,600 (273)(.101)	=	1,733	1,620 LB 113 LB
NODE PENALTY = 1,620 (.07)	=		
HALF CIRCUMFERENTIAL = 1,245 (.127)**	=	399	158 LB
TOTAL CIRCUMFERENTIAL = 1,245 (.193)**	=		241 LB
TOTAL LONGITUDINAL = 141 (.113)**			16 LB
TOTAL SIDEWALL	=		2,148 LB

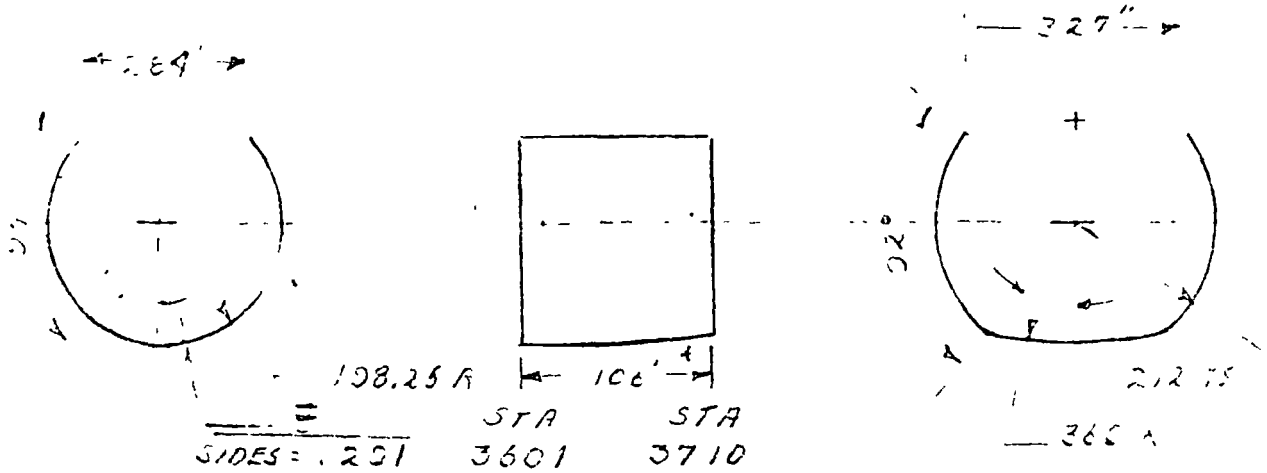
** SEE PAGE 2.3-93

ϕ SEE PAGE 2.3-94 FOR E CALCULATIONS

* THIS SKIN SECTION INCLUDES 5" WHICH IS ACTUALLY PART OF THE LH2 TANK SKIRT. THE TOTAL CIRCUMFERENTIAL JOINT IS AT STA. 3558

[illegible]

STA 3601 - 3710



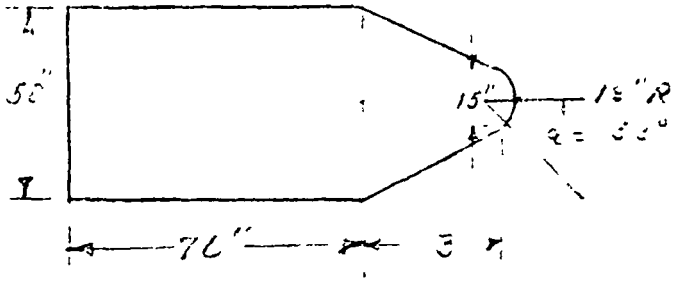
SIDES = .291
BOTTOM = .481

$$A_{REH} = 2\left[\frac{[illegible]}{[illegible]}\pi\left(\frac{396.8 + 425.8}{[illegible]}\right)(107)\right] + \frac{73}{[illegible]}\pi\left(\frac{[illegible] + 720.8}{2}\right)(107)$$

SIDES BOTTOM

$$= 71{,}400 + 40{,}700 = 112{,}100 \text{ IN}^2$$

SUBTRACT LANDING GEAR CUTOUT:



$$A_{REH} = 2\left[76(50) + \left(\frac{50 + 15.33}{2}\right) + \frac{R^2}{2}(2\alpha - \sin 2\alpha)\right]$$

$$= 2\left[3800 + 1{,}072 + \frac{18^2}{2}(1.85 - .961)\right]$$

$$= 2\left[3{,}800 + 1{,}072 + 144\right] = 10{,}032 \text{ IN}^2$$

ASSUME LANDING GEAR CUTOUT IS ENCLOSED WITH A HALF CIRCUMFERENTIAL JOINT

LENGTH = 2[50 + 152 + 100] = 604" HALF CIRCUMFERENTIAL LESS ATTACH PARTS

+ SHAFT LENGTH = 107"

THRUST STRUCTURE SIDEWALL

STA 3604 - 3710 (CONT)

CIRCUMFERENTIAL JOINTS

$$\text{LENGTH} = \frac{269}{360}\pi(398.7) + 2\left(\frac{92}{360}\right)\pi(427.74) + \frac{76}{360}\pi(722.2)$$

$$= 932 + 695 + 478 = 2095'' \text{ OF HALF JOINT}$$

LONGITUDINAL JOINT

LENGTH = 2 (107) = 214" OF HALF JOINT

LENGTH = 2 (107) = 214" OF TOTAL JOINT

SUMMARY

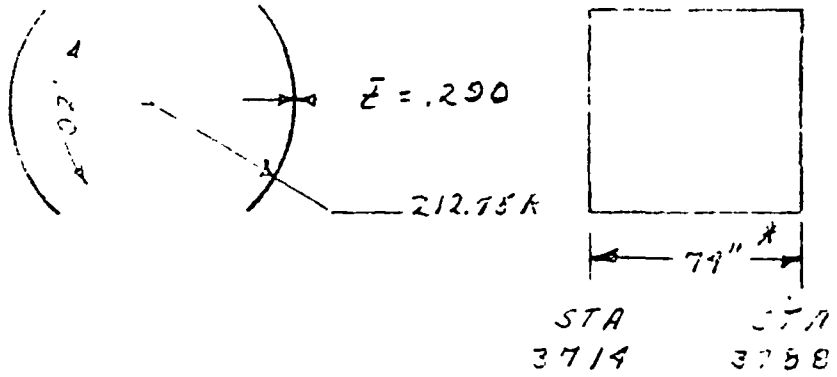
SIDEWALL - SIDES$^{\phi}$ = 71,400 (.291)(.101) =		2,080 LB
SIDEWALL - BOTTOM$^{\phi}$ = (40,700 - 10032)(.481)(.101) =	3820	1,490 LB
NODE TERMINI = 3,570 (.07) =		250 LB
HALF CIRCUMFERENTIAL = 2095 (.127)* =		343 LB
HALF LONGITUDINAL = 214 (.083)* =	382	42 LB
TOTAL LONGITUDINAL = 214 (.113)* =		24 LB
LANDING GEAR CUTOUT ENCLOSURE = 604 (.066) =		39 LB
TOTAL SIDEWALL		4,244 LB

* SEE PAGE 2.3-93

ϕ SEE PAGE 2.3-94 FOR $\bar{z}$ CALCULATIONS

THRUST STRUCTURE SIDEWALL

STA 3714 - 3788

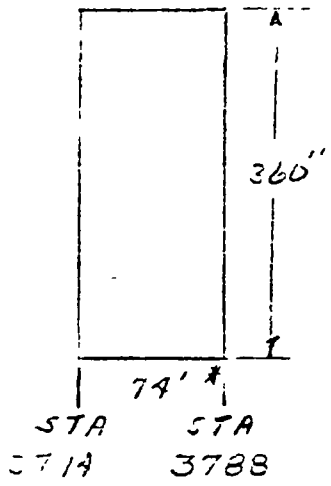


SIDE AREA:

$$\text{AREA} = 2\left[\frac{92}{360}\pi(425.9)(74)\right] = 2(\quad) = 50,400 \text{ IN}^2$$

BOTTOM SIDEWALL:

$$t =$$



$$\text{AREA} = 74.5(360) = 26,800 \text{ IN}^2$$

CIRCUMFERENTIAL JOINTS

$$\text{LENGTH} = 4\left[\frac{92}{360}\pi(427.74)\right] + 2(360) = 2,095'' \quad \text{OF HALF JOINT}$$

LONGITUDINAL JOINTS

LENGTH = 2(74) = 14.8" OF HALF JOINT

LENGTH = 2(74) = 148" OF TOTAL JOINT

* SLANT LENGTH = 74.5"

THRUST STRUCTURE SIDEWALL

STA 3714 - 3788 (CONT.)

SUMMARY

SIDEWALL - SIDES$^{\phi}$ = 50,400(.290)(.101)	=	2596	1,480 LB
SIDEWALL - BOTTOM$^{\phi}$ = 26,800(.350)(.101)	=		946 LB
NODE PENALTY = 2,426 (.07)	=		170 LB
HALF CIRCUMFERENTIAL = 2095 (.127)*	=		266 LB
HALF LONGITUDINAL = 148 (.083)*	=	29	12 LB
TOTAL LONGITUDINAL = 148 (.113)*	=		17 LB
TOTAL SIDEWALL			2,891 LB

* SEE SUMMARY BELOW

ϕ SEE PAGE 2.3-94 FOR $\bar{E}$ CALCULATIONS

AFT STRUCTURE CIRCUMFERENTIAL JOINT PENALTY

(SEE ANALYSIS FOR INTERTANK STRUCTURE)

ISOGRID PENALTY	.066
ATTACHING PARTS	.061
TOTAL FOR HALF JOINT	.127 LB/IN *
TOTAL JOINT (ADD .066) =	.193 LB/IN *

AFT STRUCTURE LONGITUDINAL JOINT PENALTY

(SEE ANALYSIS FOR INTERTANK STRUCTURE)

ISOGRID PENALTY	.030
ATTACHING PARTS	.053
TOTAL FOR HALF JOINT	.083 LB/IN *
TOTAL JOINT (ADD .030) =	.113 LB/IN *

SEE ANALYSIS IN INTERTANK WEIGHT SUBSTATIATION PAGES 2.3-75 TO 2.3-77

NOMINAL DIMENSIONS

STA	ULT. LOAD, LB/IN. COMP.	h	a	S	R_{NA}	t_s ±.005	b ±.005	w ±.005	t_F ±.005	$\bar{y}_{nom}$	$\bar{t}_{nom}$
3553-3600	10,400	8.66	10.00	2.25	198.62	.150	.090	.600	.323	.404	.2725
SIDE 3600-3710	11,250	9.37	10.82	2.50	213.12	.162	.100	.600	.338	.431	.2910
BOTTOM	11,250*	9.37	10.82	3.00	453.37	.145	.106	.860	.992	1.016	.4814
SIDE 3710-3792	11,170	9.37	10.82	2.50	213.12	.162	.100	.600	.333	.429	.2902
BOTTOM	11,170*	9.37	10.82		844.37	Δ	Δ	Δ	Δ	Δ	.950

Assume

* APPROXIMATED FROM MAX. SIDE BENDING LOAD

Δ DESIGNED AS APPROX FLAT PANELS BETWEEN BEAMS

FRAME A7 STA 3000

LEGS

(13) $t_w = 4.0$ & WIDTH = 10"

$L = 247 + 18 + 110 + 153 + 40 + 50 + 40 + 72 = 730'$

$V = (730)(4)(1)$ = 2920 IN^3

(14) $t_w = 4.0$ & WIDTH = 1/2"

$L = 19 + 19 + 22 + 10 + 36 + 25 + \frac{1}{2}(26) = 144'$

$V = (144)(4)(.50)$ = 288 IN^3

(15) $t_w = 4.0$ & WIDTH = 2.25"

$L = 104 + 54 + 76 + 30 + 73 = 374"$

$V = (374)(4)(2.25)$ = 3370 IN^3

VARIOUS ODD SHAPE SECTIONS WITH $t_w = 4.0$.

(16) $V = (21.5 + 23)(2)(4)$ = 356 IN^3

(17) $V = \frac{1}{2}(6+3)(10)(4)$ = 180 IN^3

(18) $V = \frac{1}{2}(7+3)(29)(4)$ = 580 IN^3

(19) $V = \frac{1}{2}(2+7)(18)(4)$ = 324 IN^3

(20) $V = [(4)(5)+(4)(2)+(1)(2)][4]$ = 132 IN^3

(21) $V = [\frac{1}{2}(5+2)(5)+\frac{1}{2}(2)(6.5)(8)][4]$ = 219 IN^3

(22) $V = (30)(2)(4)$ = 240 IN^3

(23) $V = [\frac{1}{2}(6)(3)(5)][4]$ = 225 IN^3

$\frac{1}{2} V_{LEGS}$ = 8900 IN^3

$V_{LEGS} = 8900 IN^3 \times 2 =$ 17,800 IN^3

$V_{FILLETS}$ (SEE NEXT PAGE) 185 IN^3

TOTAL CAP VOLUME = 17,985 IN^3

TOTAL CAP WT = 17,985(.101) = **1,816 LB**

FRAME AT STA 3600

FILLETS

PER JOHN COCKRUM
EST FILLETS @ R 1/2

(13)	L = 730 + 60 + 12 + 40	=	842
(14)	L = 144 + 16 + 19 + 22 + 10 + 36 + 21	=	278
(15)	L = 374 + 37	=	411
(16)	L = 30	=	30
(17)	L = 20	=	20
(18)	L = 27	=	27
(19)	L = 16	=	16
(20)	L = 13	=	13
(21)	L = 48	=	48
(22)	L = 21	=	21
		Σ L =	1719

TOTAL FILLET L = 1719 x 2 = 3438"

$V = .2146 (.52)^2 \times 3438 =$ 181 IN^3

FRAME AT STA 3600

WEBS
(ALL SAME t_w .200" + 50% STIFFENING & 0.005 TOL = 0.305"

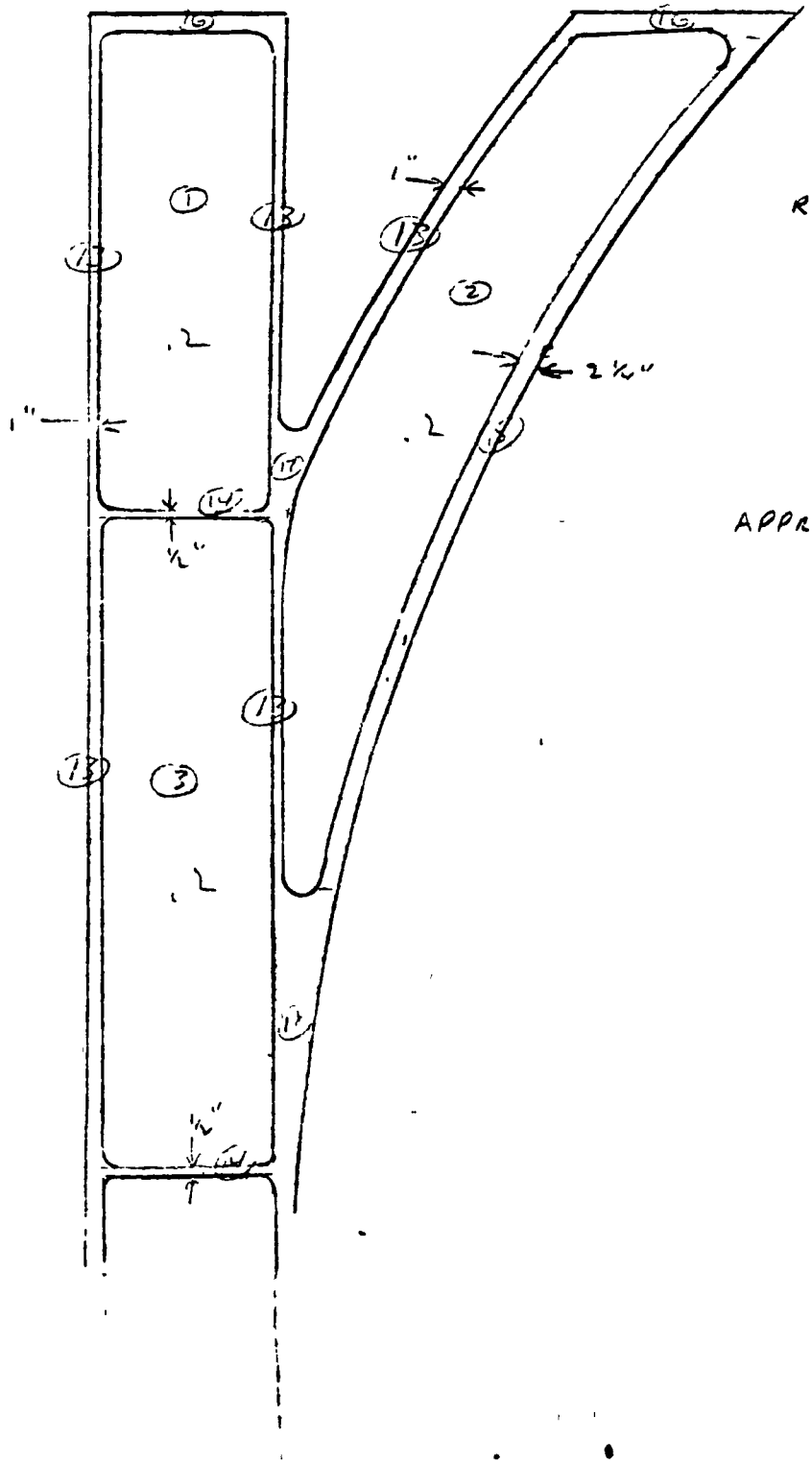
①	A = (19 X 51.5)	=	978 IN^2
②	A = ½ (20X34) + ½(15.5X34) + ½(9X20) + ½(4+15½X20) + ½(4.5+14X40.5)	=	1264 IN^2
③	A = (19X70)	=	1330 IN^2
④	A = (20X47) + (22X18)	=	1336 IN^2
⑤	A = (22X40) + ½(22+17X15) + ½(17)(6.5)	=	1228 IN^2
⑥	A = ½(2+23)(57) + ½(10X8) + ½(2+10X30)	=	1075 IN^2
⑦	A = ½(3+15X11.5)	=	104 IN^2
⑧	A = ½(17+27½X37½) + ½(13+31X34)	=	1583 IN^2
⑨	A = ½(3+15.5X26)	=	241 IN^2
⑩	A = ½(16+24X31.5) + ½(24+27X31.5)	=	1434 IN^2
⑪	A = ½(35+12X36)	=	279 IN^2
⑫	A = ½(4X26) + ½(7X26) + (59.5)(26)	=	1690 IN^2
			12542 IN^2

$\frac{1}{2} V_{WEBS} = (12{,}542\ IN^2)(.305\ IN) = 3830\ IN^3$

$V_{WEBS} = 3830\ IN^3 \times 2 = \underline{7660\ IN^3}$

TOTAL WEB WT = 7,660(.101) = **774 LB**

FRAME AT STA 3600



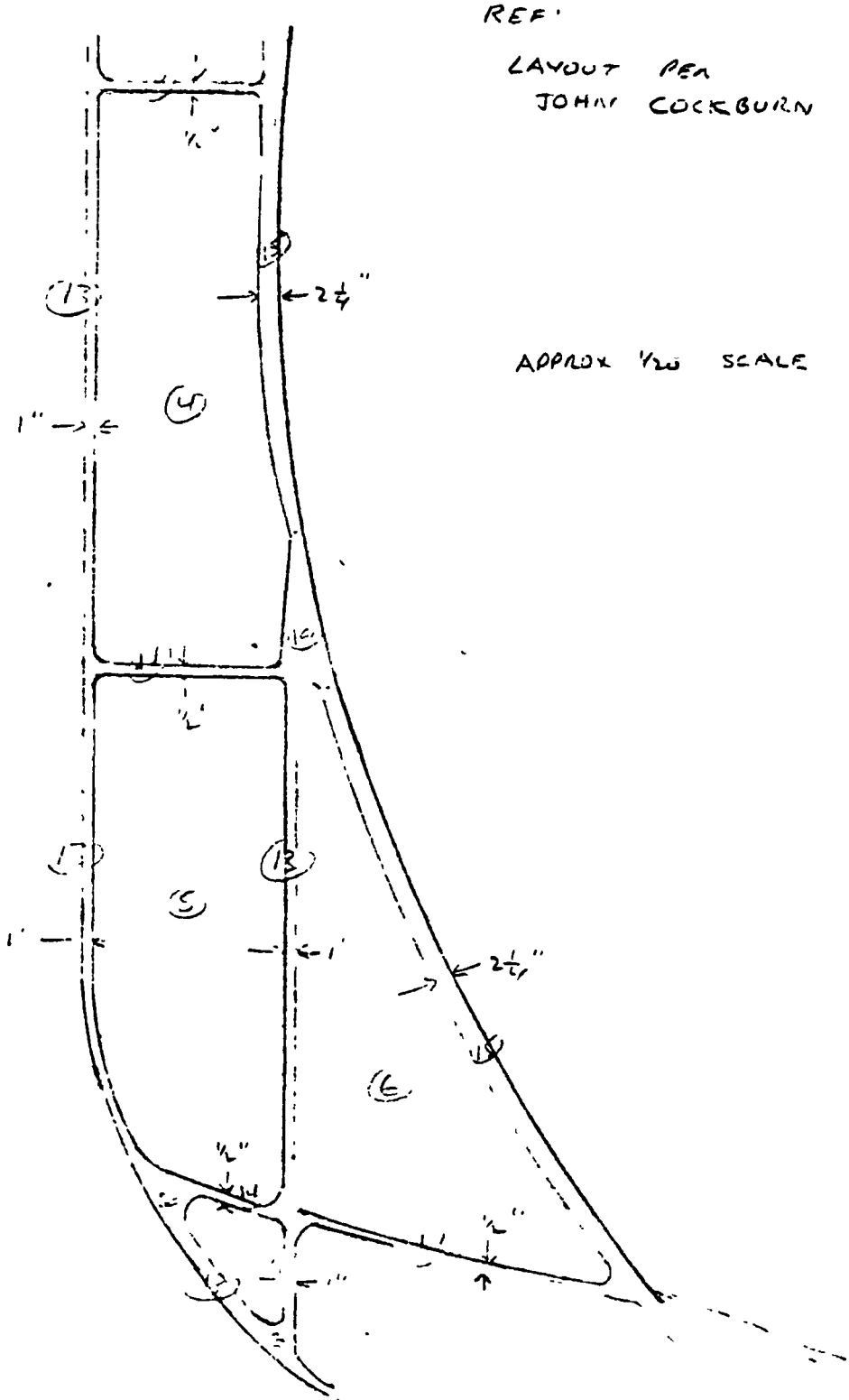
REF
LAYOUT PER
JOHN COCKBURN

APPROX 1/20 SCALE

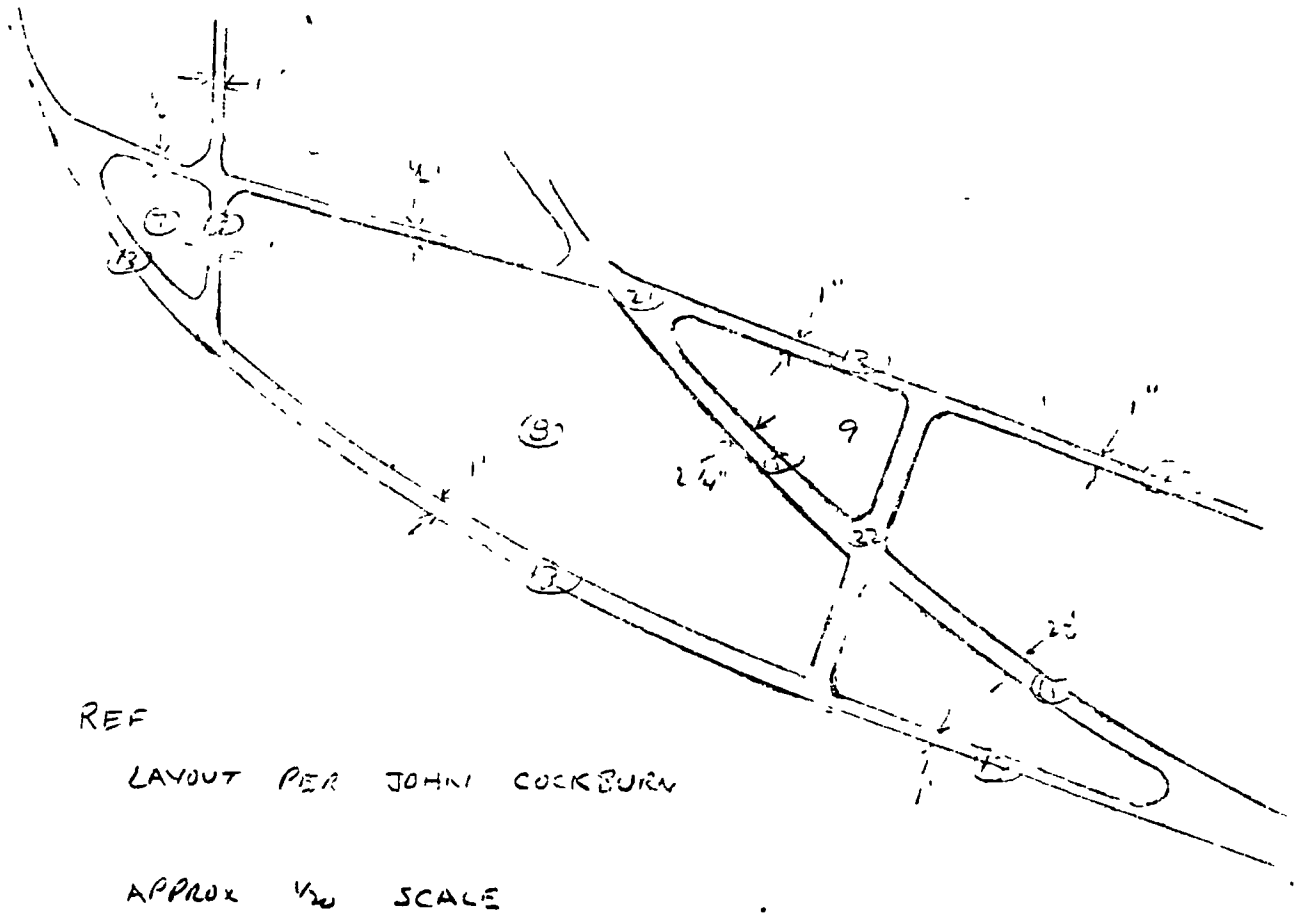
FRAME AT STA 3600

REF:
LAYOUT PER
JOHN COCKBURN

APPROX 1/20 SCALE



FRAME AT STA 3000

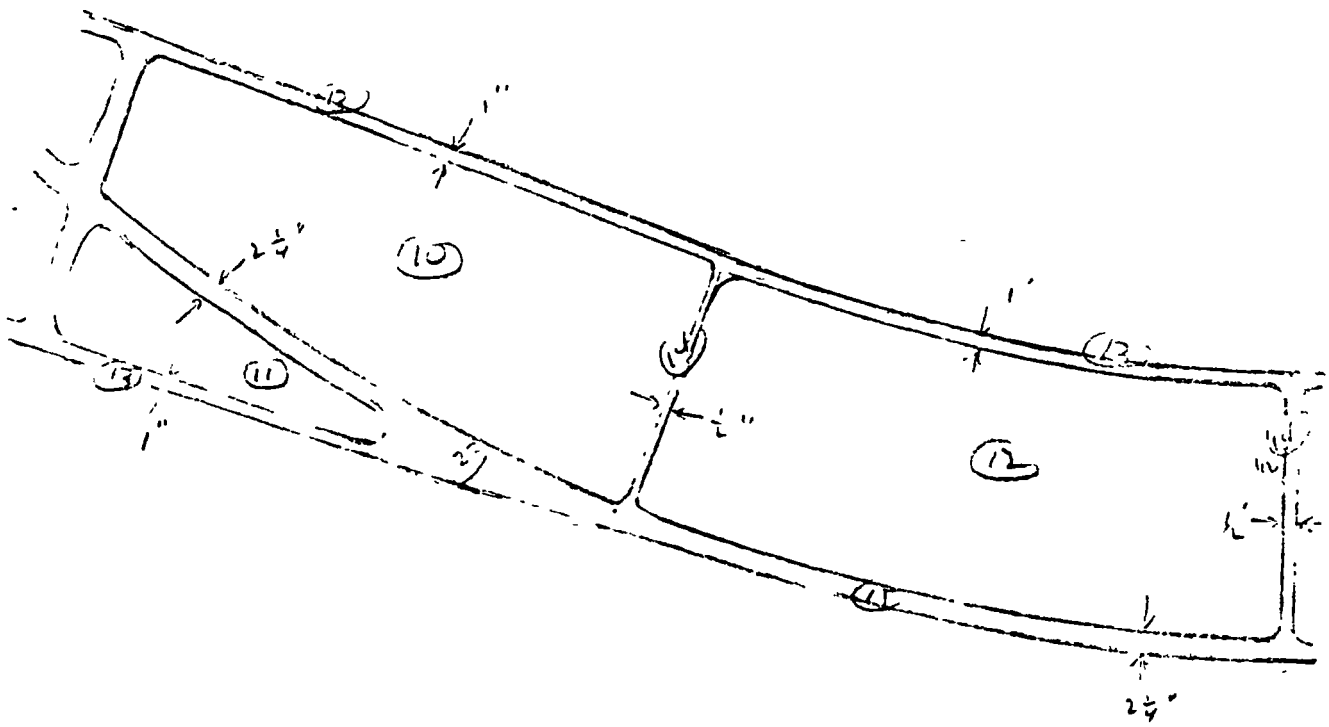


REF

LAYOUT PER JOHN COCKBURN

APPROX 1/20 SCALE

FRAME AT STA 3600



REF:

LAYOUT PER JOHN COCKBURN

APPROX ½ SCALE

FRAME AT STA 3710

LEGS

(6) $t_w = 4.0"$

$V = (9)(8)(4) = 256 \ IN^3$

(7) $t_w = 4.0"$ & WIDTH 10"

$L = 43 + 113 + 55 + 330 + 80 + 58 + 56 \times 2$

$L = 694 \ IN$

$V = (694)(4)(1) = 2776 \ IN^3$

(8) $t_w = 4.0"$ & WIDTH 2 1/4"

$L = 350"$

$V = (350)(4)(2.25) = 3150 \ IN^3$

(9) $t_w = 2.0$ & WIDTH 8"

$L = 293"$

$V = (293)(2)(8) = 4690 \ IN^3$

(10) $t_w = 4.0$ & WIDTH 1/2"

$L = 43 + 49 \times 4 - 40 + 45 + 42 + \frac{1}{2}(44)$

$L = 388"$

$V = (388)(.5)(4) + (.5)(8)(5) = 796 \ IN^3$

$\frac{1}{2} V_{LEGS} = 11,668 \ IN^3$

$V_{LEGS} = 11,668 \ IN^3 \times 2 = 23,336 \ IN^3$

$V_{FILLETS}$ (SEE PAGE 2.3-103) $= 238 \ IN^3$

V_{SPLICE} (SEE PAGE 2.3-104) $= 278 \ IN^3$

TOTAL CAP VOLUME $= 23,852 \ IN^3$

REF DRWG NO 256-20-0002

ALL t & W PER CR APPLE BAUGH

TOTAL CAP WT $= 23,852 (.101) =$ **2,410 LB**

AFT FRAME AT STA 3710

PER JOHN COCKBURN
EST FILLET AT ½"R

FILLET VOLUME

$V_1 = .2146 (.50)^2 \times 419.4^* = 225$

$V_2 = .2146 (.50)^2 \times 4" \times 30 \times 2 = 13$

FILLET V_T = 238 IN^3

* INCLUDES BOTH SIDES (SEE LENGTH BELOW)

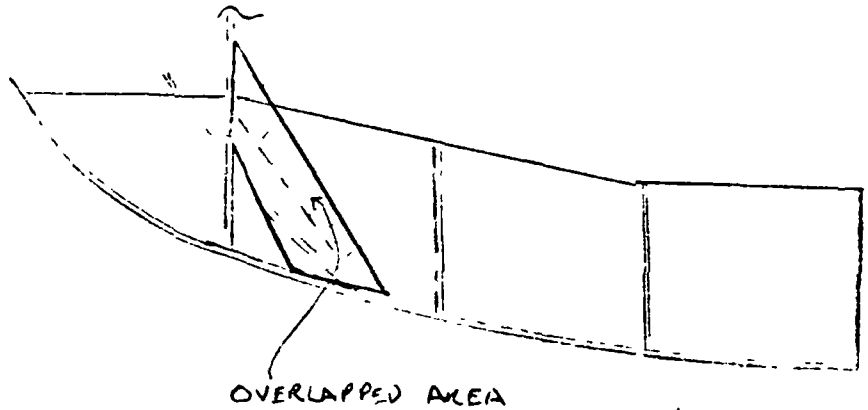
FILLET LENGTH (SEE PAGE 2.3-106)

	LENGTH
⑦	694"
⑧	700"
⑨	293"
⑩	410"
TOTAL	2,097 x 2 = 4,194"

FRAME AT STA 3710

PER JOHN COCKBURN

ADDED SPLICE TYPE AREA IN LOWER SECTION



OVERLAPPED AREA
.4"t IN LIEU OF .2"t ($\Delta t = .2$"
ASSUME .305"t

AREA = APPROX 7" x 65"

$\Delta WT = 2[7 \times 65 (.305 \times .101)] = +28$ LBS

OR $\Delta V = 2[7 \times 65 (.305)] = 278$ IN^3

FRAME AT STA 3710

WEBS

(ALL SAME t_w .200" + 50 % STIFFENING ∓0.005 TOL.

= .305" t_w

① $A = (8)(44) + (243)(52) - .785(19) \times 2 = 12,069\ IN^2$

② $A = \frac{1}{2}(54)(52) - (8)(35) = 1,124\ IN^2$

③ $A = \frac{1}{2}(12)(53) + \frac{1}{2}(17)(53) + (53)(30) = 2,359\ IN^2$

④ $A = \frac{1}{2}(9)(55) \times 2 + (55)(34) = 2,365\ IN^2$

⑤ $A = \frac{1}{2}(2)(54) \times 2 + (54)(42) = 2,376\ IN^2$

$A_T = 20,293\ IN^2$

$\frac{1}{2}\ V_{WEBS} = (20,293\ IN^2)(.305\ IN) = 6190\ IN^3$

$V_{WEBS} = 6190\ IN^3 \times 2 = 12,380\ IN^3$

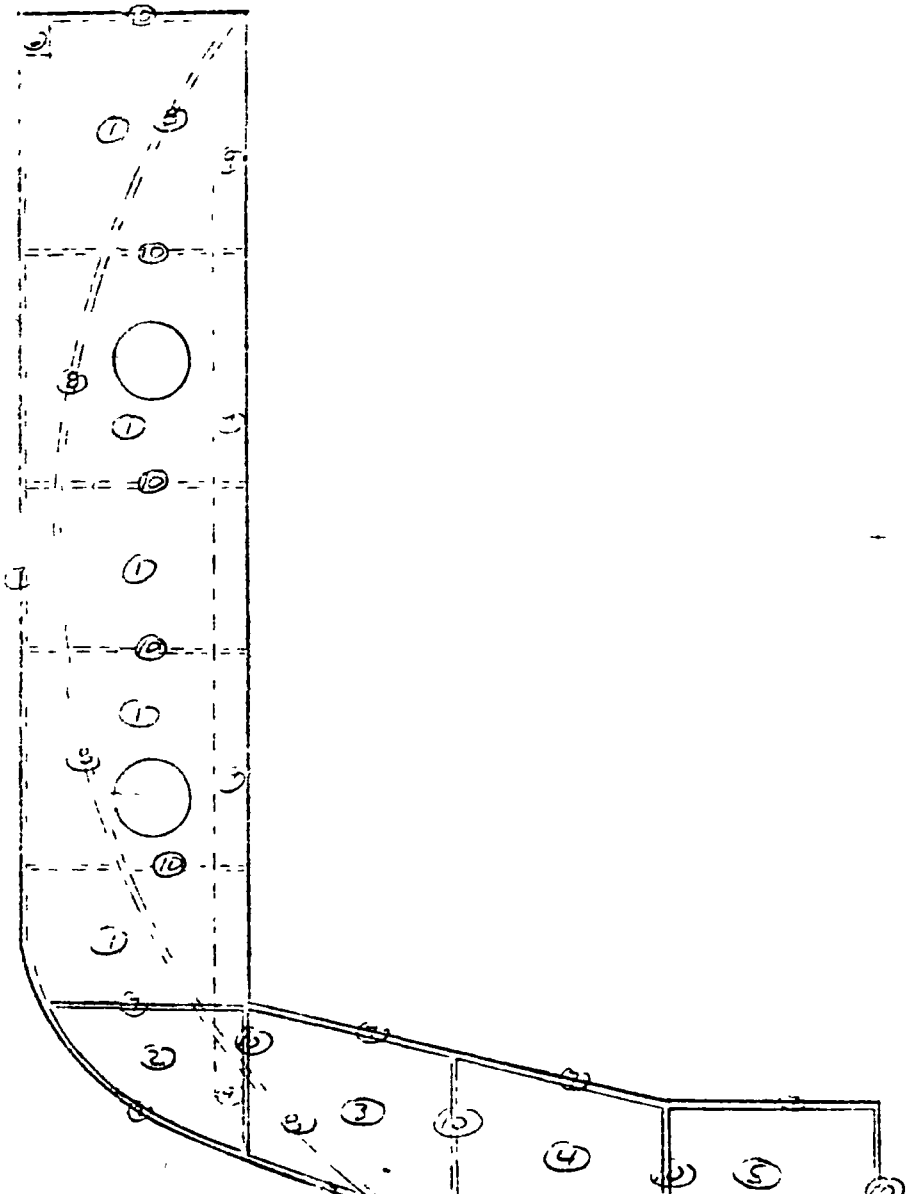
TOTAL WEB WT = 12,380 (.101) = **1,250 LB**

REF DRWG NO. 256-20-0002

ALL t & w PER C. R. APPLEBAUGH

FRAME AT STA 3710

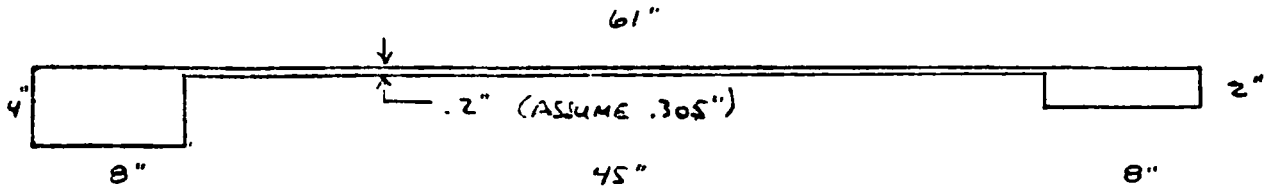
REF: DRWG NO. 256-20-0002



APPROX 1/50 SCALE

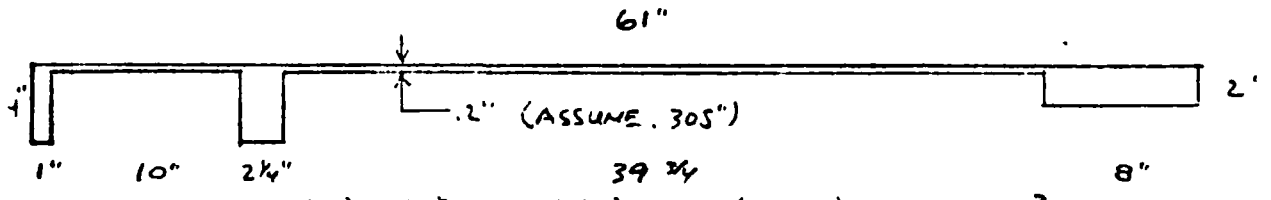
FRAME AT STA 3710

① AT UPPER SECTION (E:T)



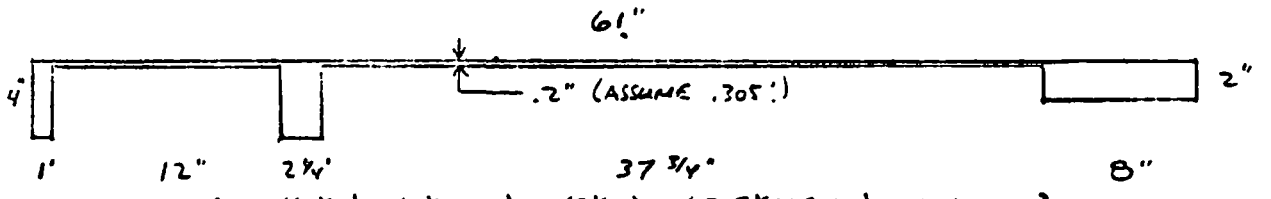
$A = (4)(8) + (.305)(45) + (2)(8) = 61.7\ in^2$

② AT APPROX 110" FROM TOP (E:T)



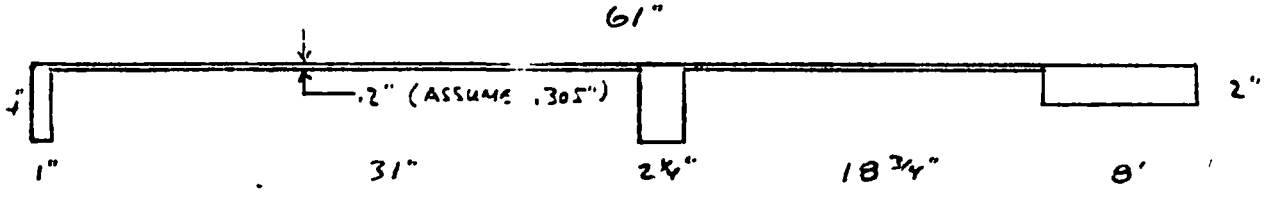
$A = (4)(1) + (4)(2.25) + (8)(2) + .305(49.75) = 44.2\ in^2$

③ AT APPROX 180" FROM TOP (E:T)



$A = (4)(1) + (4)(2.25) + (8)(2) + (.305)(49.75) = 44.2\ in^2$

④ AT APPROX 235" FROM TOP (E:T)



$A = (4)(1) + (4)(2.25) + (8)(2) + (.305)(49.75) = 44.2\ in^2$

REF: DRWG NO. 25G-20-0052
T & W PER C.R. APPLEBAUGH

AFT FRAME AT STA 3772

LEGS

⑨ t_w = 4.0"
$V = (11)(13)(4) - .785(3)^2(4)$ = 445 IN^3

⑩ t_w = 4.0" & WIDTH TAPERS FROM 2½" TO 1"
$V = \frac{1}{2}(2.5+1.0)(1.27)(4)$ = 890 IN^3

⑩ t_w = 4.0"
$V = (2.5)(10.2)(4)$ = 1020 IN^3

⑪ t_w = 4.0"
$V = (2.25)(28.8)(4)$ = 2590 IN^3

⑫ t_w = 2.0"
$V = (8)(26.2)(2) + (3)(35)(2)$ = 4400 IN^3

⑬ t_w = 2.0"
$V = \frac{1}{2}(9+18)(35)(2)$ = 945 IN^3

⑭ t_w = 4.0"
$V = (1)(30.5)(4)$ = 1460 IN^3

⑮ t_w = 4.0"
$V = (.50)(490)(4)$ = 980 IN^3

⑯ t_w = 4.0"
& WIDTH TAPERS FROM 1" TO 3"
$V = \frac{1}{2}(1+3)(58)(4)$ = 464 IN^3

⑰ t_w = 4.0
& WIDTH TAPERS FROM 3" TO 1½"
$V = \frac{1}{2}(3+1.5)(112)(4)$ = 1010 IN^3

⑱ t_w = 4.0
& WIDTH TAPERS FROM 1½" TO 1"
$V = \frac{1}{2}(1.5+1.0)(58)(4)$ = 290 IN^3

14484 IN^3

LEGS

TOTAL VOLUME = 14484 IN^3 x 2 = 28,968 IN^3
FILLET VOLUME (SEE NEXT PAGE) = 307 IN^3
TOTAL CAP VOLUME = 29,275 IN^3

TOTAL CAP WT = 29,275(.101) = **2,957 LB**

NOTE: ALL t & W PER C.L. APPLEBAUGH

REF: DRWG NO. 256-20-0002

AFT FRAME AT STA 3792

PER JOHN COCKBURN

EST FILLETS V_L & R

FILLET VOLUME

$V_1 = .2146(.10)^2 \times 5436^{*} = 292$

$V_L = .2146(.10)^2 \times 4'' \times 36 \times 2 = 15$

FILLET $V_T = 307\ IN^3$

* INCLUDES BOTH SIDES (SEE LENGTH BELOW)

FILLET LENGTH (SEE PAGE 2.3-111)

	LENGTH
(9)	127
(14)	365
(10)	204
(11)	576
(5)	900
(6)	116
(7)	112
(8)	56
(12)	262
TOTAL	2,718" x 2 = 5,436"

AFT FRAME AT STA 3792

WEBS

① t_w = 500 (ASSUME .755)*
$V = \frac{1}{2}(6+14)(102)(.755) = 770\ IN^3$

② t_w = .200 (ASSUME 305)*
$V = \frac{1}{2}(44)(98)(.305) = 657\ IN^3$

③ t_w = .200 (ASSUME .305)*
$V = [\frac{1}{2}(98)(98) - .785(14)^2][.305] = 630\ IN^3$

④ t_w = .200 (ASSUME .305)*
$V = [55(112) - .785(14)^2][.305] = 1790\ IN^3$

⑤ t_w = .200 (ASSUME .305)*
$V = (55)(61)(.305) = 1023\ IN^3$

⑥ t_w = .200 (ASSUME .305)*
$V = [\frac{1}{2}(107)(6) + (105)(31) + \frac{1}{2}(104)(16)][.305] = 1347\ IN^3$

⑦ t_w = .350 (ASSUME .530)*
$V = (56)(47)(.530) = 1395\ IN^3$

$7612\ IN^3$

WEBS
TOTAL VOLUME = $7612\ IN^3 \times 2 = 15,224\ IN^3$

TOTAL WEB WT = 15,224(.101) = **1,538 LB**

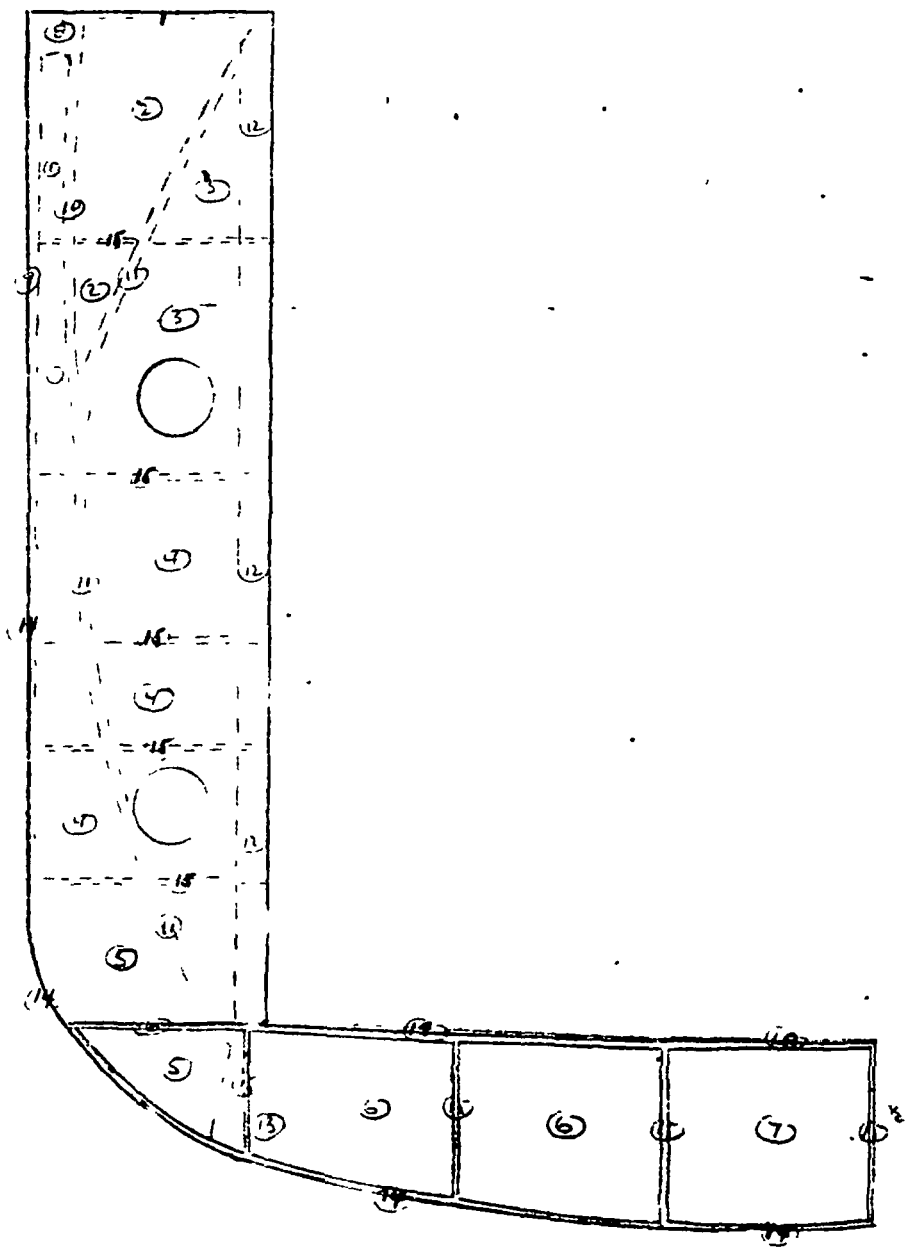
REF: DRWG NO 256-20-0002

* INCLUDES 50% STIFFENING & 0.005" TOLERANCE

NOTE: ALL C & W PER C.R APPLEBAUGH

AFT FRAME AT STA 3792

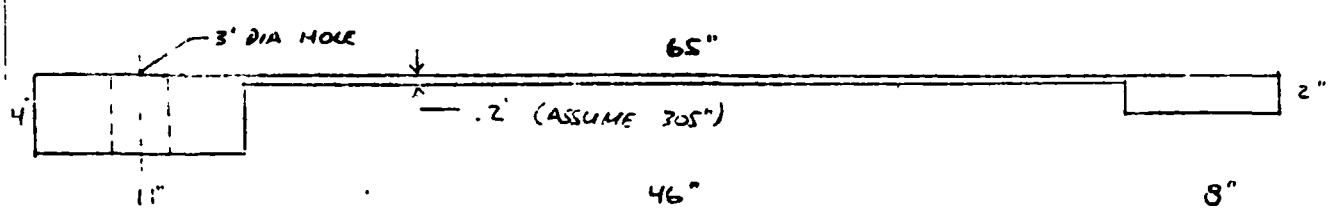
REF. DRWG NO. 256-20-0002



APPROX 1/50 SCALE

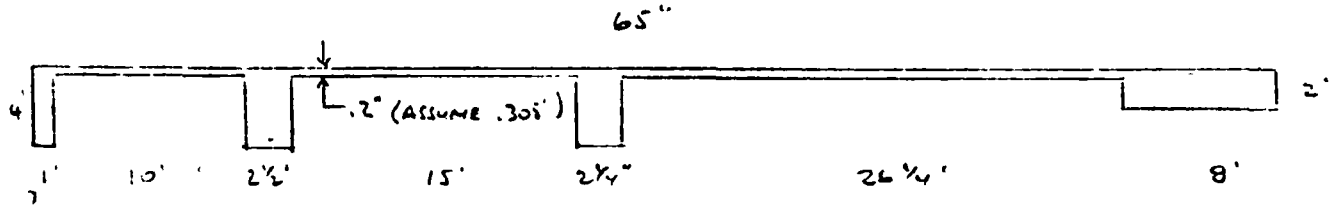
AFT FRAME AT STA 3792

① AT UPPER SECTION



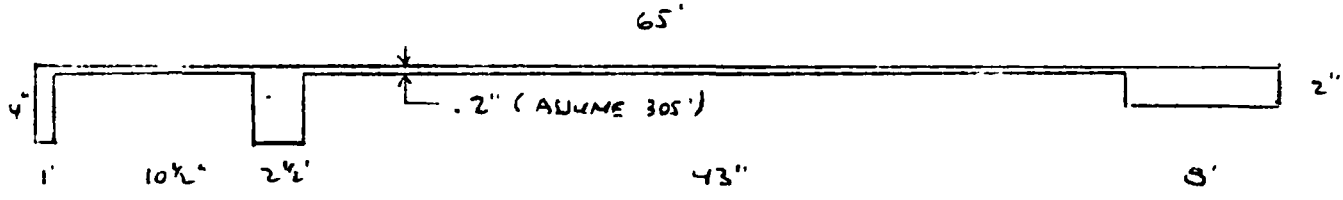
$A = (4)(11) + (.305)(46) + (2)(8) = 74 \text{ IN}^2$ (NOT INCLUDING 3" DIA HOLE)

② AT WEB APPROX 59" FROM TOP



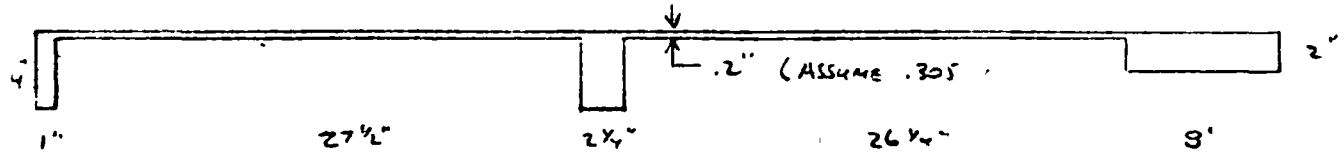
$A = (4)(1) + (4)(2.5) + 4(2.25) + (2)(8) + (.305)(51.25) = 54.6 \text{ IN}^2$

③ AT SECTION B-B



$A = (4)(1) + (4)(2.5) + (2)(8) + (.305)(53.5) = 46.3 \text{ IN}^2$

④ AT SECTION C-C



$A = (4)(1) + (4)(2.25) + (2)(8) + (.305)(53.75) = 45.4 \text{ IN}^2$

REF: DRWG NO. 256-20-0002

SUPPORTS FOR FRAMES AT STA 3600, STA 3710 & STA 3792

SUMMARY

	REQUIRED PER LOCATION	LOCATED BELOW TOP OF FRAME AT APPROXIMATELY 58"	114"	226"	TOTAL WEIGHT
STA 3600 FRAME	2	38.0 LBS	20.2 LBS	38.0 LBS	96.2 LBS
STA 3710 FRAME	2	30.8 LBS		30.8 LBS	61.6 LBS
STA 3792 FRAME	2	32.4 LBS		32.4 LBS	64.8 LBS

SUPPORTS FOR FRAMES
AT STA 3600, STA 3710, & STA 3792

1. SUPPORTS FOR FRAME AT STA 3600
   LOCATED AT 3 PLACES
   1. APPROX 226" & 59" BELOW TOP OF FRAME, L = 47"
   2 APPROX 114 BELOW TOP OF FRAME, L = 25'

   MATERIAL ALUMINUM (.101 LB/IN^3)

   1. WT = (2)(2)(47)(.101) = 19.0 LB/EA
   2. WT = (2)(2)(25)(.101) = 10.1 LB/EA

2. SUPPORTS FOR FRAME AT STA 3710
   LOCATED AT 2 PLACES
   APPROX 226" & 59" BELOW TOP OF FRAME
   ASSUME SAME LENGTHS (L=39") AT BOTH LOCATIONS

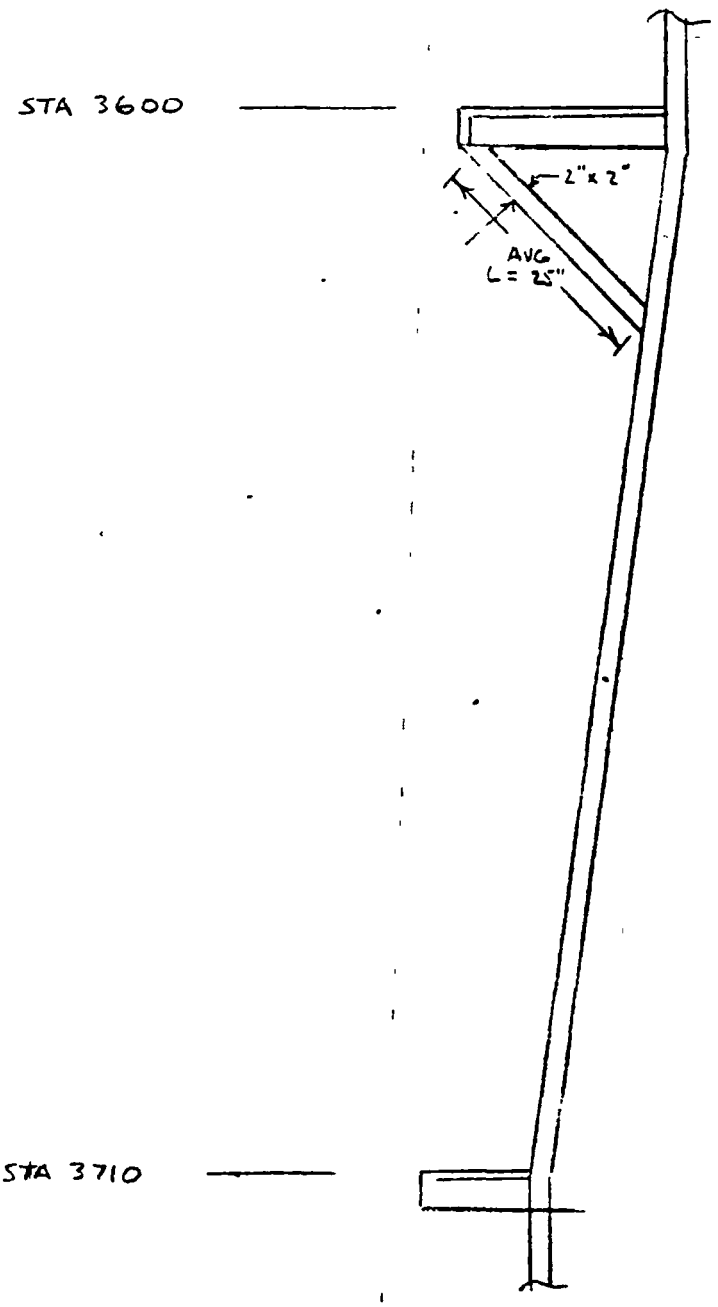
   WT = (2)(2)(39)(.101) = 15.4 LB/EA

3. SUPPORTS FOR FRAME AT STA 3792
   LOCATED AT 2 PLACES
   APPROX 226' & 59' BELOW TOP OF FRAME
   ASSUME SAME LENGTHS (L=40") AT BOTH LOCATIONS

   WT = (2)(2)(40)(.101) = 16.2 LB/EA

REF: DRWG NO. 256-20-0002
& C.R. APPLEBAUGH

SUPPORT FOR FRAME AT STA 3600

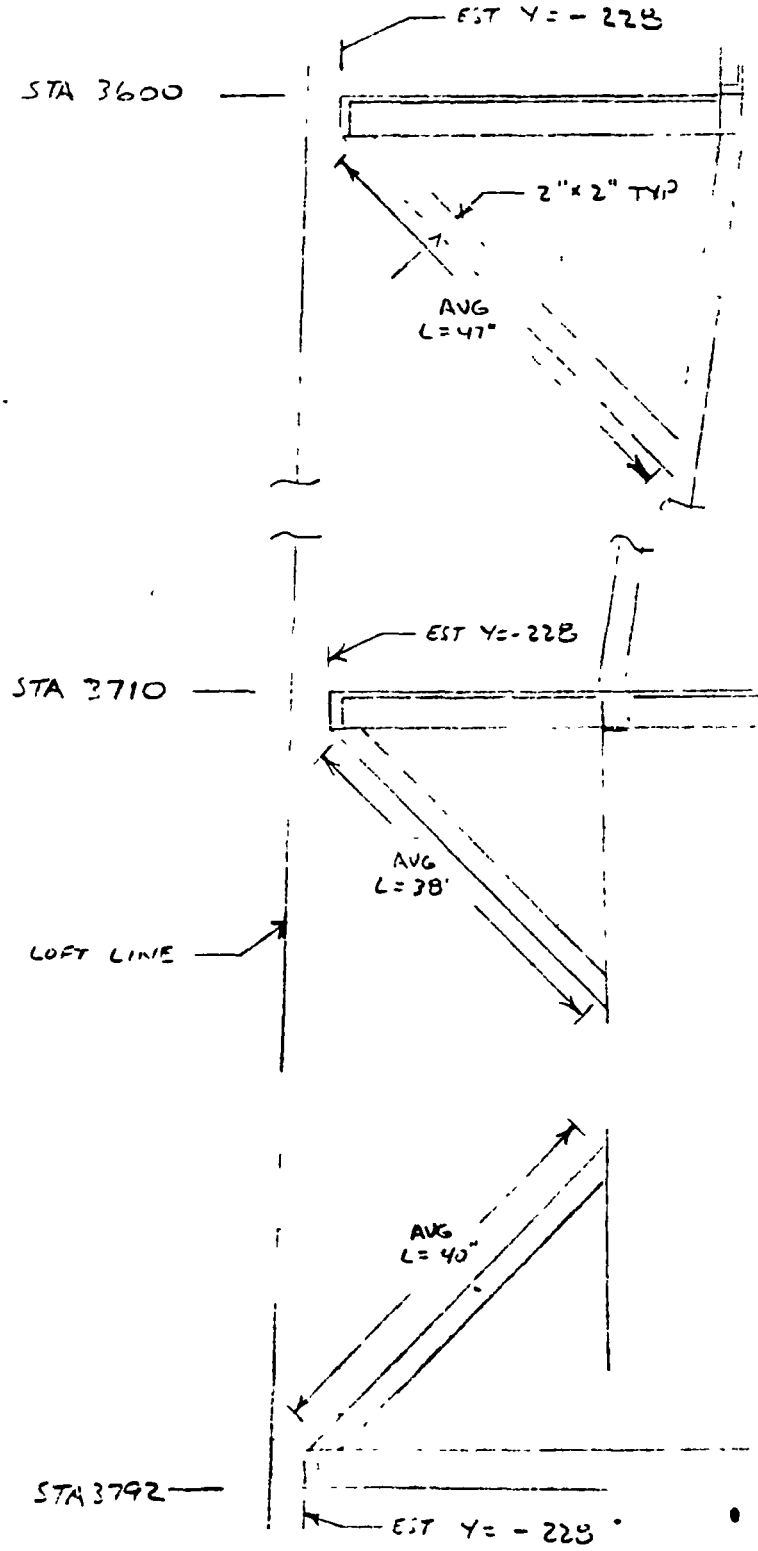


AT SECTION B-B
APPROX 114" BELOW
TOP OF FRAME

APPROX 1/20 SCALE

REF: DRWG NO. 256-20-0002

SUPPORTS FOR FRAMES
AT STA 3600, STA 3710, & STA 3792



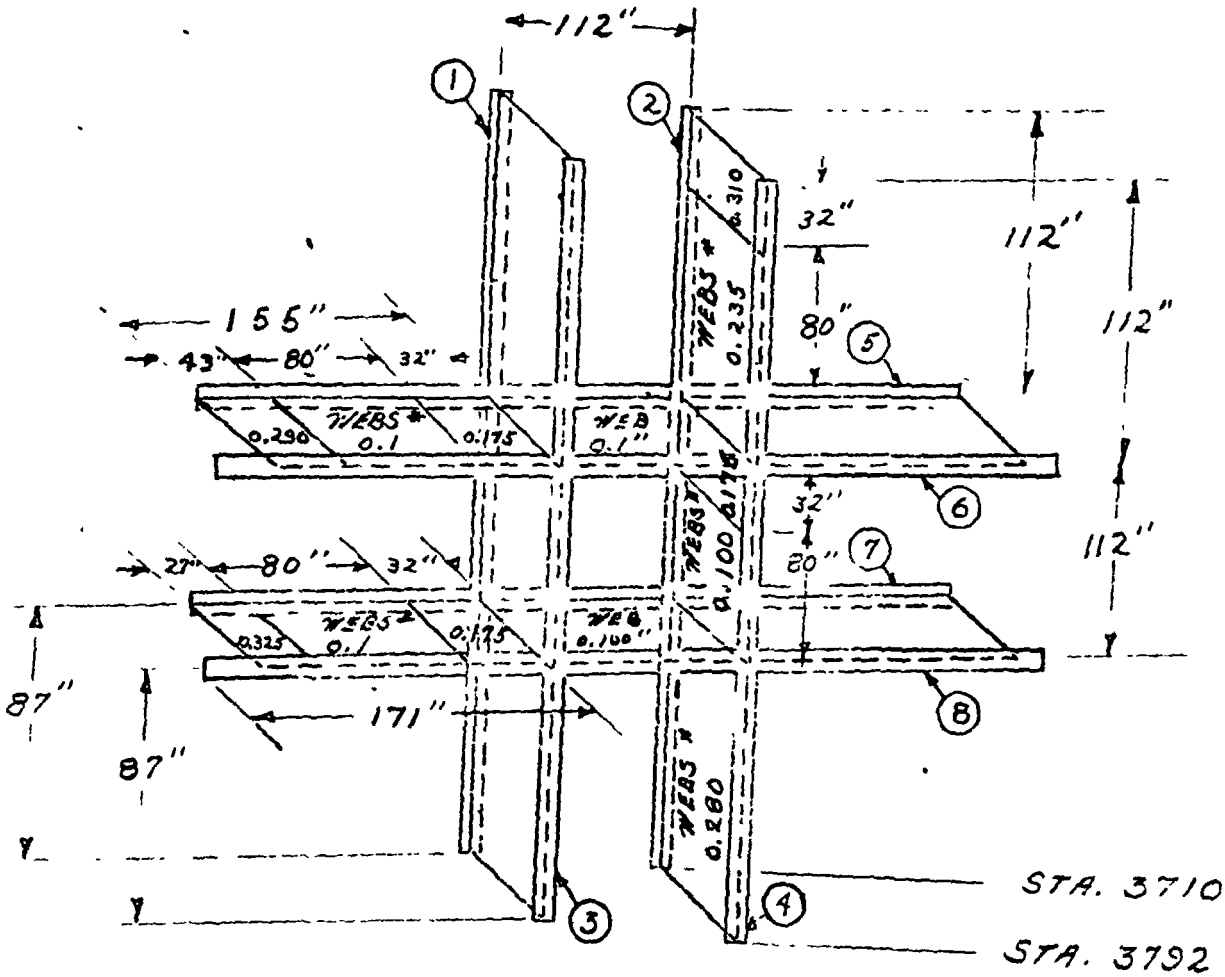
AT SECTION C-C
APPROX 226" BELOW
TOP OF FRAME

ASSUME SAME LENGTHS
FOR LOCATION 58"
BELOW TOP OF FRAME

APPROX 1/20 SCALE

REF: DRWG NO. 254-20-0002

CENTER BEAM-WEB STRUCTURE
MATERIAL: ALUMINUM 7075



○ BEAM IDENTIFICATION NO.

* TYPICAL BOTH SIDES

BEAMS ①, ②, ③, ④

- THESE BEAMS ARE IDENTICAL
  LENGTH = 311"
  WIDTH = 9" TYPICAL + BEEF-UP AT ENGINE MOUNT
  THICKNESS = 2"

  WT = LWT + BEEF-UP
  = 311(5)(2)(.101) + [2(15)(3)(2) + 2(6)(5) + 2(20)3].101 = 539 LB/BEAM

  TOTAL = 4(539) = 2,155 LB

BEAMS ⑤, ⑦

THESE BEAMS ARE IDENTICAL
LENGTH = 422"
WIDTH = 3" TYPICAL + BEEF-UP AT ENGINE MOUNT
THICKNESS = 1"

WT = LWT + BEEF-UP
= 422(8)(1)(.101) + 4(15)(3)(1)(.101) = 359 LB/BEAM

TOTAL = 2(359) = 718 LB

BEAMS ⑥, ⑧

THESE BEAMS ARE IDENTICAL
LENGTH = 454"
WIDTH = 3" TYPICAL + BEEF-UP AT ENGINE MOUNT
THICKNESS = 1"

WT = LWT + BEEF-UP
= 454(8)(1)(.101) + 4(15)(3)(1)(.101) = 385 LB/BEAM

TOTAL = 2(385) = 770 LB

TOTAL **3643 LB**

WEBS-MIDDLE HORIZONTAL - LEFT TO RIGHT

OUTER ENDS

$\bar{t}$ = 0.290 + 50% STIFFENING = .435 MIN = .440" NOM ± 0.005

WT = 2(43)(78)(.440)(.101) = 298 LB

CENTER SECTION & MIDDLE OF OUTER PANEL

$\bar{t}$ = 0.100 + 50% STIFFENING = .150 MIN = .155" NOM ± 0.005

L = 2(60) + 112 = 272"

WT = 272(7.5)(.155)(.101) = 332 LB

INNER SECTION OF OUTER PANEL

$\bar{t}$ = 0.175 + 50% STIFFENING = .263 MIN = .268 NOM ± 0.005

WT = 2(25)(78)(.268)(.101) = 135 LB

TOTAL UPPER HORIZONTAL WEB 765 LB

WEBS-LOWER HORIZONTAL - LEFT TO RIGHT

OUTER ENDS

$\bar{t}$ = 0.325 + 50% STIFFENING = .488 MIN = .493 NOM ± 0.005

WT = 2(27)(79)(.493)(.101) = 210 LB

CENTER SECTION & MIDDLE OF OUTER PANEL

$\bar{t}$ = 0.100 + 50% STIFFENING = .150 MIN = .155 NOM ± 0.005

L = 2(80) + 112 = 272"

WT = 272(7.5)(.155)(.101) = 332 LB

INNER SECTION OF OUTER PANEL

$\bar{t}$ = 0.175 + 50% STIFFENING = .263 MIN = .268 NOM ± 0.005

WT = 2(32)(78)(.268)(.101) = 135 LB

TOTAL LOWER HORIZONTAL WEB 677 LB

WEBS-INBOARD VERTICAL - TOP TO BOTTOM

BOTH SIDES ARE THE SAME

UPPER TOP SECTION

$\bar{t}$ = .310 + 50% STIFFENING = .465 MIN = .470 NOM ± 0.005

WT = 2(32)(78)(.470)(.101) = 234 LB

LOWER TOP SECTION

$\bar{t}$ = .235 + 50% STIFFENING = .353 MIN = .358 NOM ± 0.005

WT = 2(80)(78)(.358)(.101) = 450 LB

WEBS - INBOARD VERTICAL (CONT.)

UPPER MIDDLE SECTION

$\bar{t}$ = .175 + 50 % STIFFENING = .263 MIN = 268 NOM ± 0.005

WT = 2(32)(78)(.268)(.101) = 135 LB

LOWER MIDDLE SECTION

$\bar{t}$ = .100 + 50 % STIFFENING = .150 MIN = .155 NOM ± 0.005

WT = 2(80)(78)(.155)(.101) = 196 LB

BOTTOM SECTION

$\bar{t}$ = .280 + 50 % STIFFENING = .420 MIN = .425 NOM ± 0.005

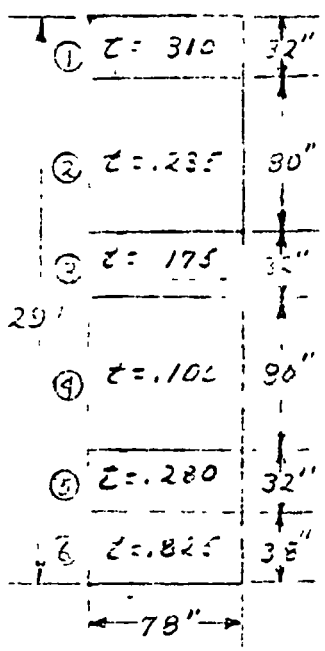
WT = 2(87)(78)(.425)(.101) = 583 LB

TOTAL INBOARD VERTICAL WEB 1598 LB

SUMMARY

UPPER HORIZONTAL	765
LOWER HORIZONTAL	677
INBOARD VERTICAL	1598
TOTAL CENTER WEB	3040 LB

OUTBOARD VERTICAL WEBS



BOTH SIDES ARE IDENTICAL

① $t = .310 + 50\%$ STIFFENING $= .465_{MIN} = .470_{NOM} \pm 0.005$
$WT = 2(78)(32)(.470)(.101) =$ 237 LB

② $t = .235 + 50\%$ STIFFENING $= .353_{MIN} = .358_{NOM} \pm 0.005$
$WT = 2(78)(80)(.358)(.101) =$ 451 LB

③ $t = .175 + 50\%$ STIFFENING $= .263_{MIN} = .268_{NOM} \pm 0.005$
$WT = 2(78)(32)(.268)(.101) =$ 135 LB

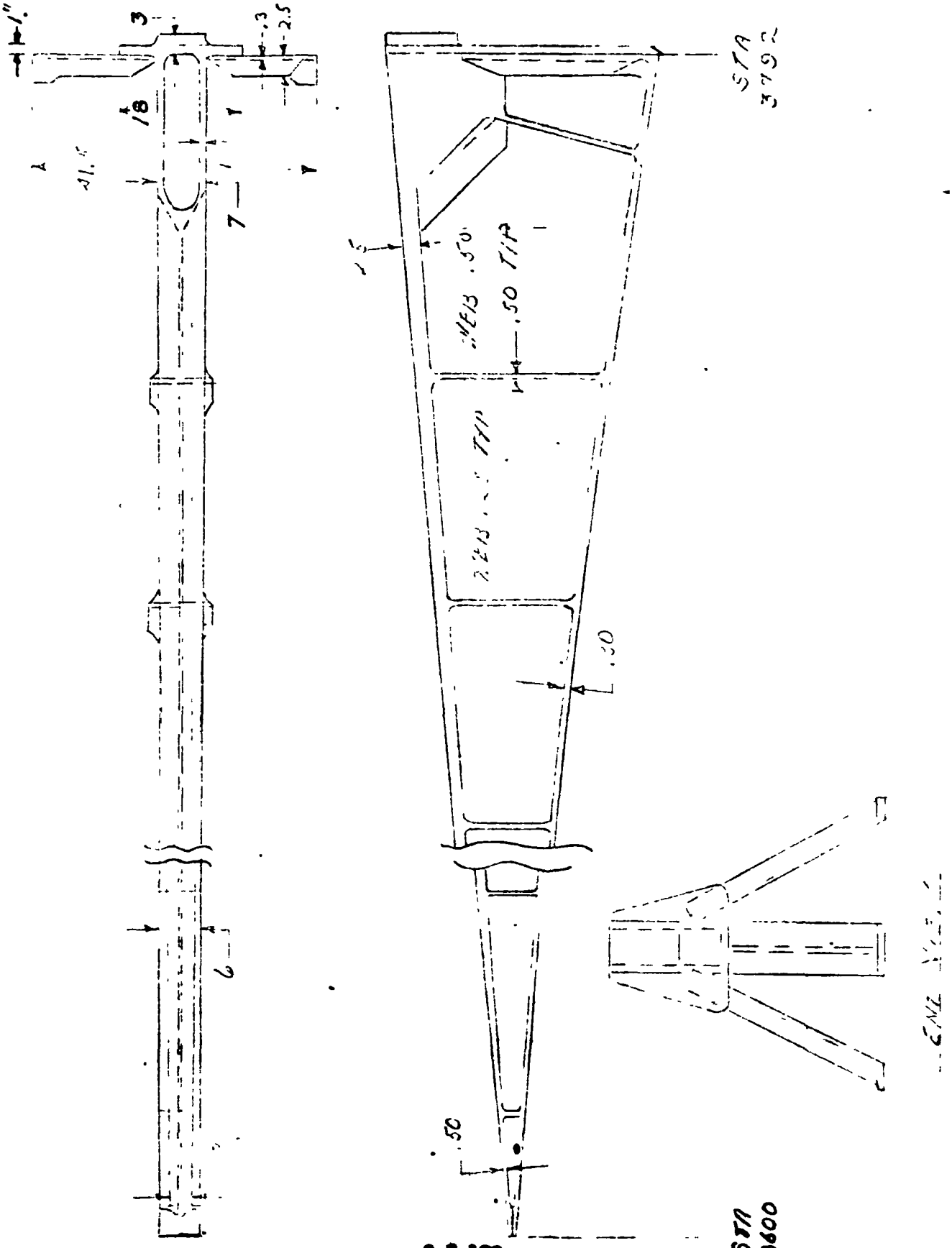
④ $t = .100 + 50\%$ STIFFENING $= .150_{MIN} = .155_{NOM} \pm 0.005$
$WT = 2(78)(80)(.155)(.101) =$ 195 LB

⑤ $t = .280 + 50\%$ STIFFENING $= .420_{MIN} = .425_{NOM} \pm 0.005$
$WT = 2(78)(32)(.425)(.101) =$ 214 LB

⑥ $t = 825 + 50\%$ STIFFENING $= 1.238_{MIN} = 1.243_{NOM} \pm 0.005$
$WT = 2(78)(38)(1.243)(.101) =$ 745 LB

TOTAL OUTBOARD VERTICAL WEB **1977 LB**

UPPER LAUNCH FITTINGS - 2 REQ - TITANIUM



BOTTOM BAND

VOLUME = 193 (6 + 7)(.3) + [(1.5)(12) + 1(10)].3 = 385

UPPER BEAM - STA 3600 - 3770

VOLUME = 170/6 [17.5 + 1.5 + 4(7.5)] = 1,385

VERTICAL WEB

VOLUME = [6(3 + 9) + 7(18 + 25 + 21)].5 = 257

[illegible] WEB

$\bar{t}$ = [illegible] STIFFENING = .375 MIN = .380 NOM ± 0.005

AREA = 141 (1 + 25) = 1,835 IN²

VOLUME = 1,835 (.38) = 698

[illegible] WEB

$\bar{t}$ = [illegible] STIFFENING = .75 MIN = .755 NOM ± 0.005

AREA = (25 + [illegible]) 21 + 6(8) + (17 + 21) 22 = 1043 IN²

VOLUME = 1043 (.755) = 78[illegible]

FITTING POCKET

VOLUME = 2[3(21) + 15(8) + 5(6.5)] 1
+ 7(3)(16)(1) + 1.5(2) 17 + 8(5)(1)
= 484 + 151 + 51 + 40 = 726

PART AFT OF STA 3792

VOLUME = [(10 + 19)(17.5) + 7(23)] 1 + 7(10)(2) = 555

SUPPORT STRUTS

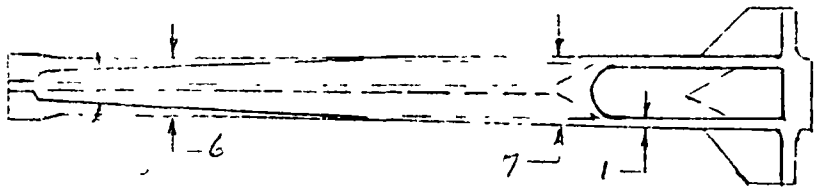
CROSS SECTION = 4.7(.3) = 1.41 IN²

VOLUME = 2[(33)(1.41) + 3(4)(1.25)] = 123

TOTAL VOLUME = 4,917 IN³

TOTAL WT OF UPPER FITTINGS = 2(4,917)(.161) = **1,580 LB**

LOWER LAUNCH FITTINGS - TITANIUM



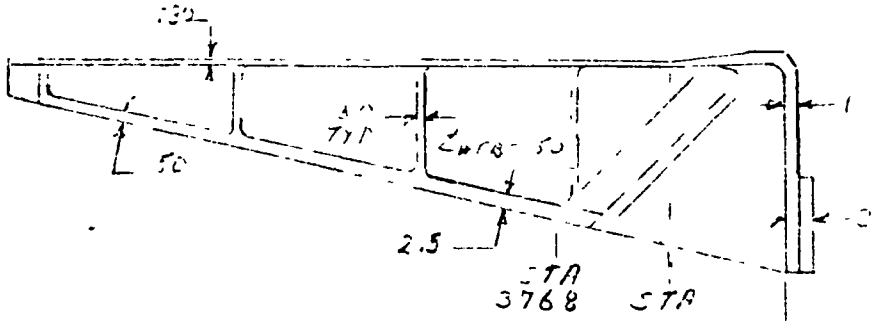


FIG 2.3-51

BOTTOM BEAM - STA 3710 - 3785

VOLUME = 70(6)(.3) = 126

UPPER BEAM - STA 3710 - 3768

VOLUME = $\frac{56}{6}[17.5 + 1.5 + 4(7.5)]$ = 458

VERTICAL WEB

VOLUME = 1(4)4 + 5.5(3+7)(.5) + 6(11+19)(.5) = 107

DIAGONAL WEB

t = .5 + 50% STIFFENING = .75 MIN = .755 NOM ± .005

VOLUME = $\left[\left(\frac{2+14}{2}\right)(55) + 6.5(13)\right].755$ = 417

FITTING POCKET

VOLUME = $2\left[\left(\frac{5+19}{2}\right) + 3(19)\right]1 + \pi(3)(21)1$

$+ 1.5(2)(23) + 6(5)(1) + 5(5)(1)$

$+ 4(6)(.5) + 4(15)(1.75)$

$= 139 + 198 + 69 + 30 + 25 + 12 + 14$ = 599

PLATE AFT OF STA 3792

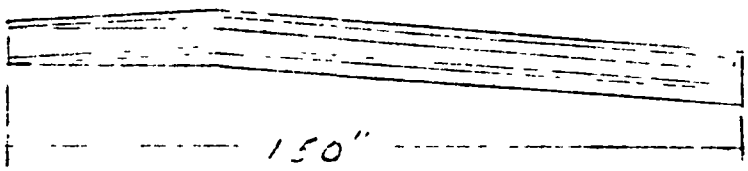
VOLUME = $\left[\left(\frac{13+36}{2}\right)19 + 2(18)\right]1 + 7(10)2$ = 442

TOTAL VOLUME 2,149 IN^3

TOTAL WT OF LOWER FITTINGS = 2(2,149)(161) = **692 LB**

LAUNCH LOAD DISTRIBUTION FITTING

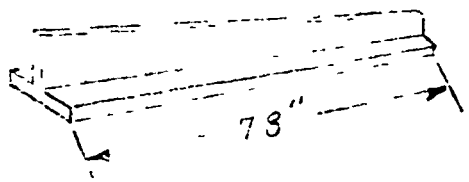
2 REQUIRED



CROSS SECTION VARIES FROM [illegible] IN^2 TO [illegible]

$WT = 2\left[\left(\frac{11+4}{2}\right)150\right].101 =$ **728 LB**

BOATTAIL LOAD STIFFENERS

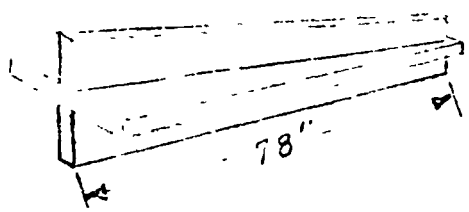


THESE MEMBERS ARE ADDED TO PROVIDE ADDITIONAL SUPPORT FOR THE ENGINE ACTUATOR LOADS - TWO/ENGINE

CROSS SECTION AREA VARIES FROM 5 IN² ON ONE END TO 1.5 IN² ON THE OTHER

$$WT = 24(78)\left(\frac{5+1.5}{2}\right)(.101) = 613 \text{ LB}$$

ENGINE LOAD STIFFENERS

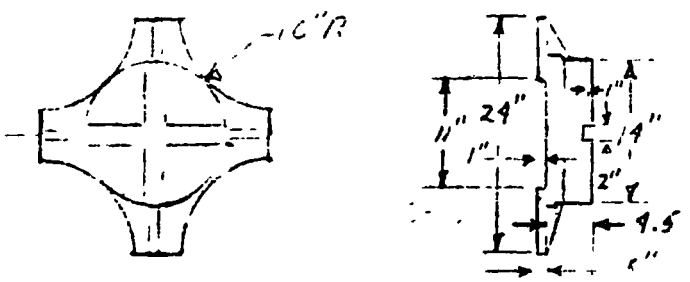


THESE MEMBERS ARE ADDED TO PROVIDE SUPPORT FOR THE ENGINE THRUST LOADS - 12 REQUIRED

CROSS SECTION AREA VARIES FROM 16.5 IN² ON ONE END TO 3 IN² ON THE OTHER

$$WT = 12(78)\left(\frac{16.5+3}{2}\right)(.101) = 922 \text{ LB}$$

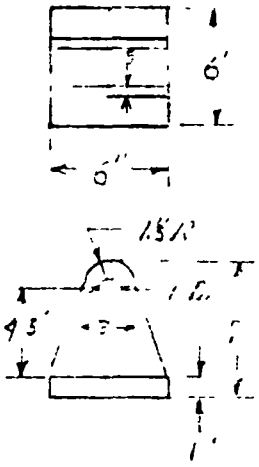
ENGINE MOUNTING FITTING



$$\text{VOLUME} = \left[4(24)(1) - \pi(10)^2\right].5 - \pi/4(11)^2(1) + \pi/4(14)^2 4.5 - 26(2)1 + 4(5)(.5) = 689 \text{ IN}^3/\text{FITTING}$$

$$WT = 12(689)(.101) = 835 \text{ LB}$$

[illegible] FITTING



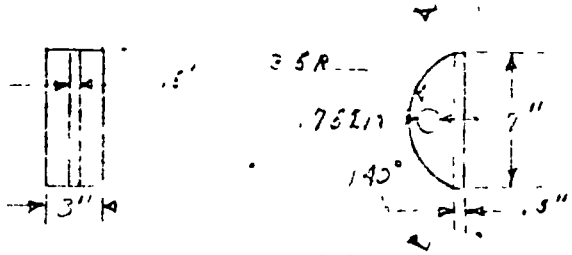
24 REQUIRED - AL

$$\text{VOLUME} = 6(6)\,1 + 2\left[\overset{3.53}{\pi/2\,(1.5)^2} - \overset{.785}{\pi/4\,(1)^2}\right. + \left(\frac{3+6}{2}\right)\overset{20.13}{(4.5)}(\ldots) =$$

$$= 36 + 2(24.615).5 \quad 61\ \text{IN}^3/\text{FITTING}$$

$$WT = 24(61)(.101) = \boxed{149\ \text{LB}}$$

[illegible] FITTING



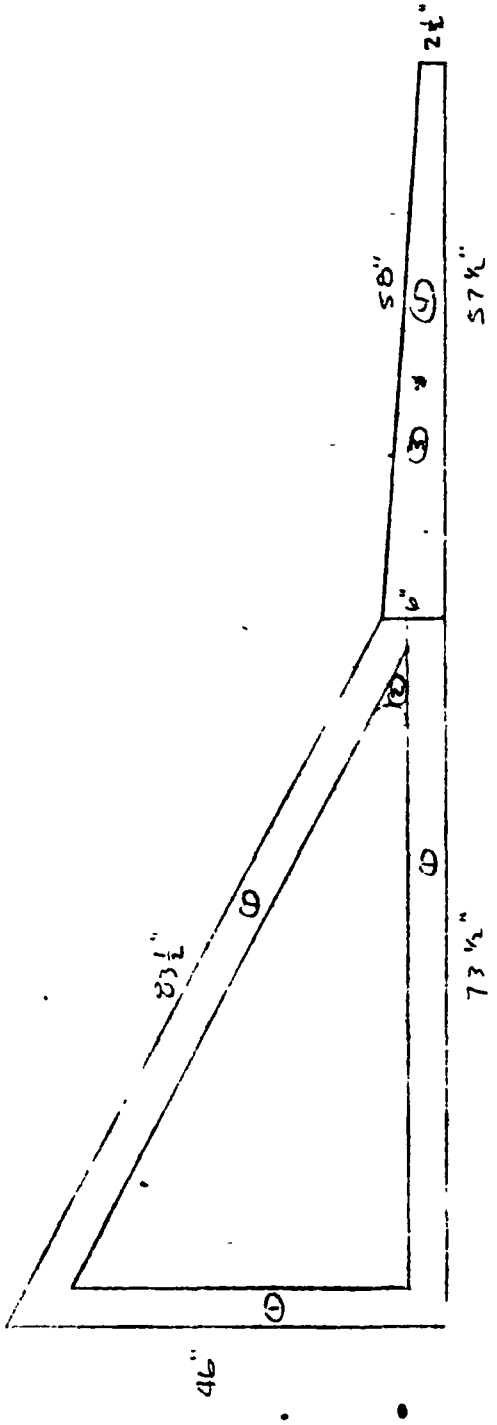
17 REQUIRED - AL

$$\text{VOLUME} = 3(7)(.5) + 14.3/360\,\overset{7.48}{\pi(3.5)^2}.5 - 7(1)(.5) - \overset{22}{\pi/4(.75)}(.5)$$

$$= 14.3\ \text{IN}^3/\text{FITTING}$$

$$WT = 17(14.3)(.101) = \boxed{25\ \text{LB}}$$

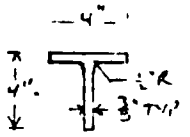
BOAT TAIL SUPPORT FITTINGS



REF: R. K YEE
DRWG NO 256-20-0002

BOAT TAIL SKIRT FITTINGS

10 REQUIRED)



AL EXTRUSION

$A = (4)(.375) + (3.625)(.375) + .2146(.5)^2 \times 2$

$A = 2.97\ IN^2$

$L_1 = 46 + 69.5 + 78 = 193.5"$

$V_1 = (193.5\ IN)(2.97\ IN^2) = 575.0$

$V_2 = \frac{1}{2}(4)(7.5)(.375) = 5.6$

$V_3 = [(4)(.375) + .2146(.5)^2 \times 2][58 + 57.5] = 186.0$

$V_4 = -\frac{1}{2}(5.25 + 1.75)(5.75)(.375) = 75.5$

$V_T = 842.1\ IN^3$

$WT/EA = (842.1\ IN^3)(.101\ LB/IN^3) = 85.1\ LBS$

$WT/10 = 85.1\ LBS \times 10 = \boxed{851\ LBS}$

30AT TAIL PANELS

FROM STA 3792 TO STA 3935
& $\bar{t}$ = .125" (ALUMINUM) ISOGRID

ITEM 1. 6 PANELS 112" WIDE

V_1 = (112 IN)(143 IN)(.125 IN) × 6 = 12,020 IN^3

ITEM 2. 8 PANELS AT CORNERS, SPLICED

(a.) LOWER CORNERS
EST 230" WIDE/EA CORNER

V_2 = (230 IN)(143 IN)(.125 IN) × 2 = 8,230 IN^3

(b.) UPPER CORNERS
AT STA 3935
EST 230" WIDE/EA CORNER
AT STA 3792
EST 222" WIDE/EA CORNER
OR AVG WIDTH = 226"

V_3 = (226 IN)(143 IN)(.125 IN) × 2 = 8,100 IN^3

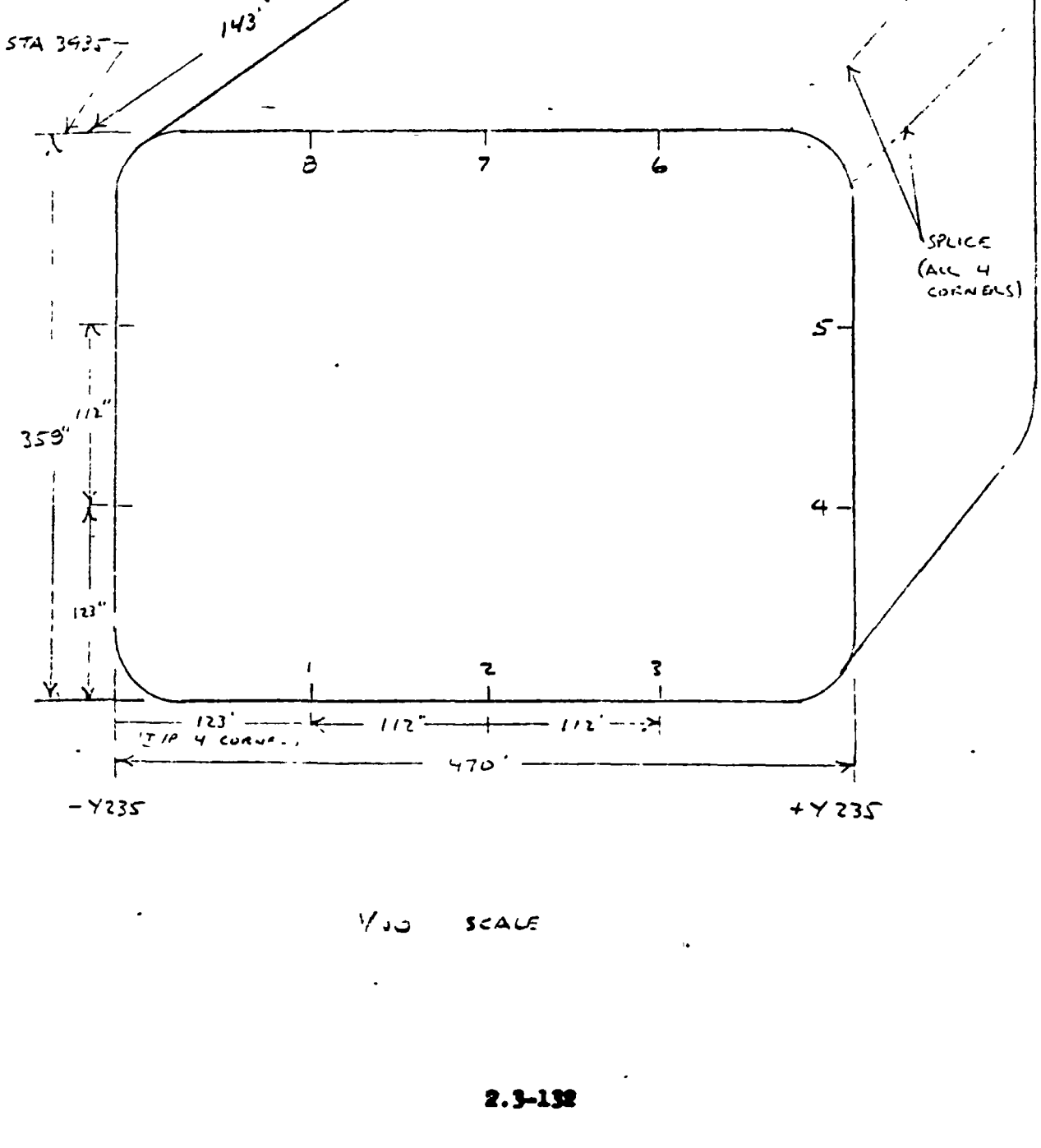
V_T = 28,350 IN^3

WT_1 = 28,350 IN^3 × .101 LB/IN^3 = 2870 LBS

WT_2 (SPLICING 8 CORNER PANELS)
UNIT WT = .113 LB/IN
WT_2 = (143) × 8 × .113 LB/IN = 129 LBS

TOTAL WT **2999 LBS**

BOAT TAIL PANELS

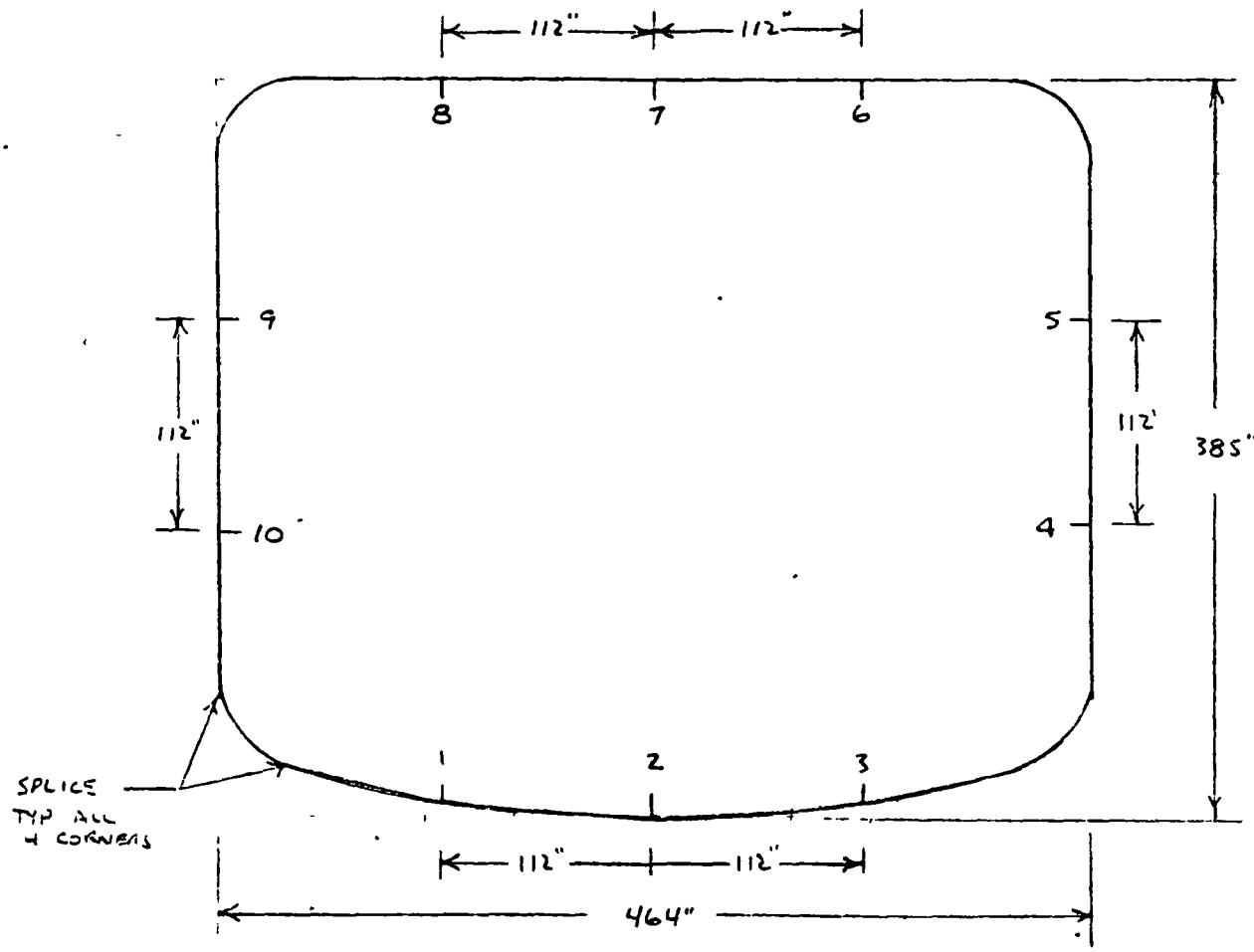


1/30 SCALE

BOAT TAIL PANELS

FROM STA 3792 TO STA 3935

$\bar{t}$ = 125



AT STATION 3792

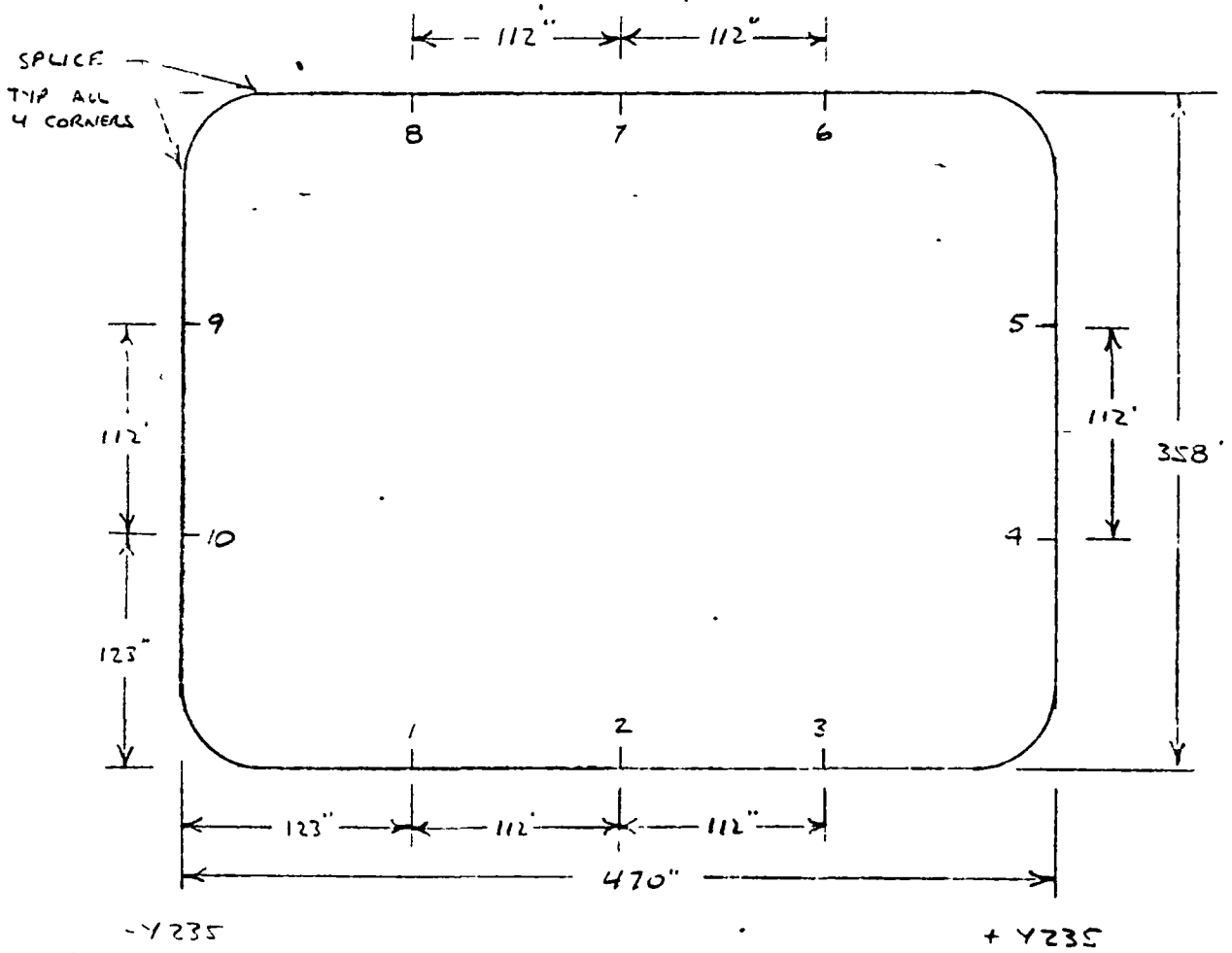
APPRX 1/100 SCALE

REF: DRWG 256-20-0002
DRWG 256-20-0003

BOAT TAIL PANELS

FROM STA 3792 TO STA 3935

$\bar{t}$ = .125

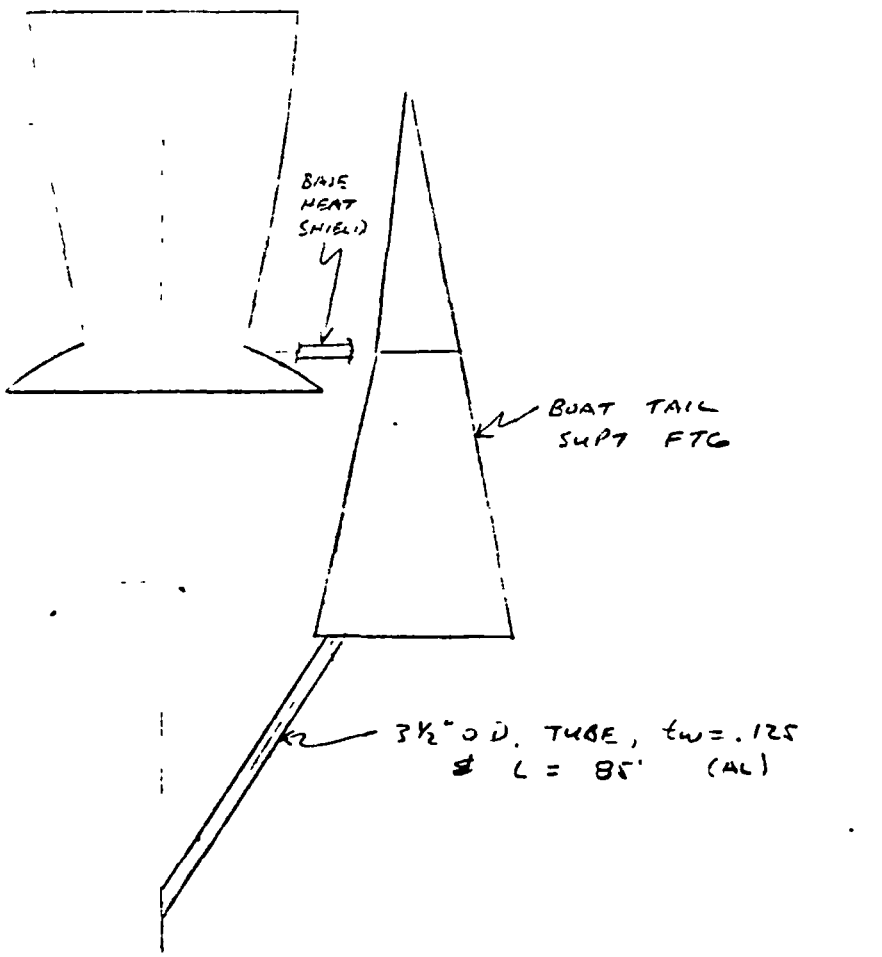


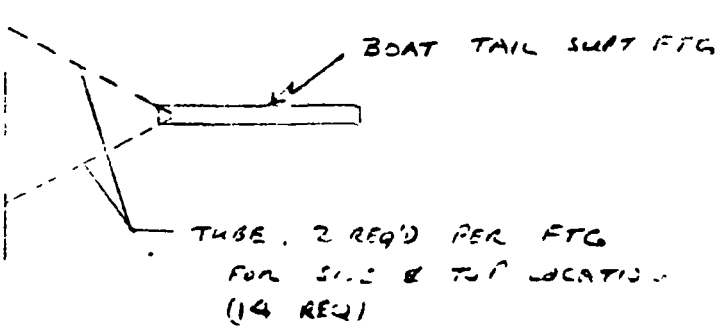
AT STATION 3935

APPROX 1/100 SCALE

REF DRWG 250-20-0002
DRWG 256-20-0002

STRUTS FOR BOAT TAIL SUPT FITTINGS





STRUTS

REQUIRED FOR BOAT TAIL SUPT FITTINGS

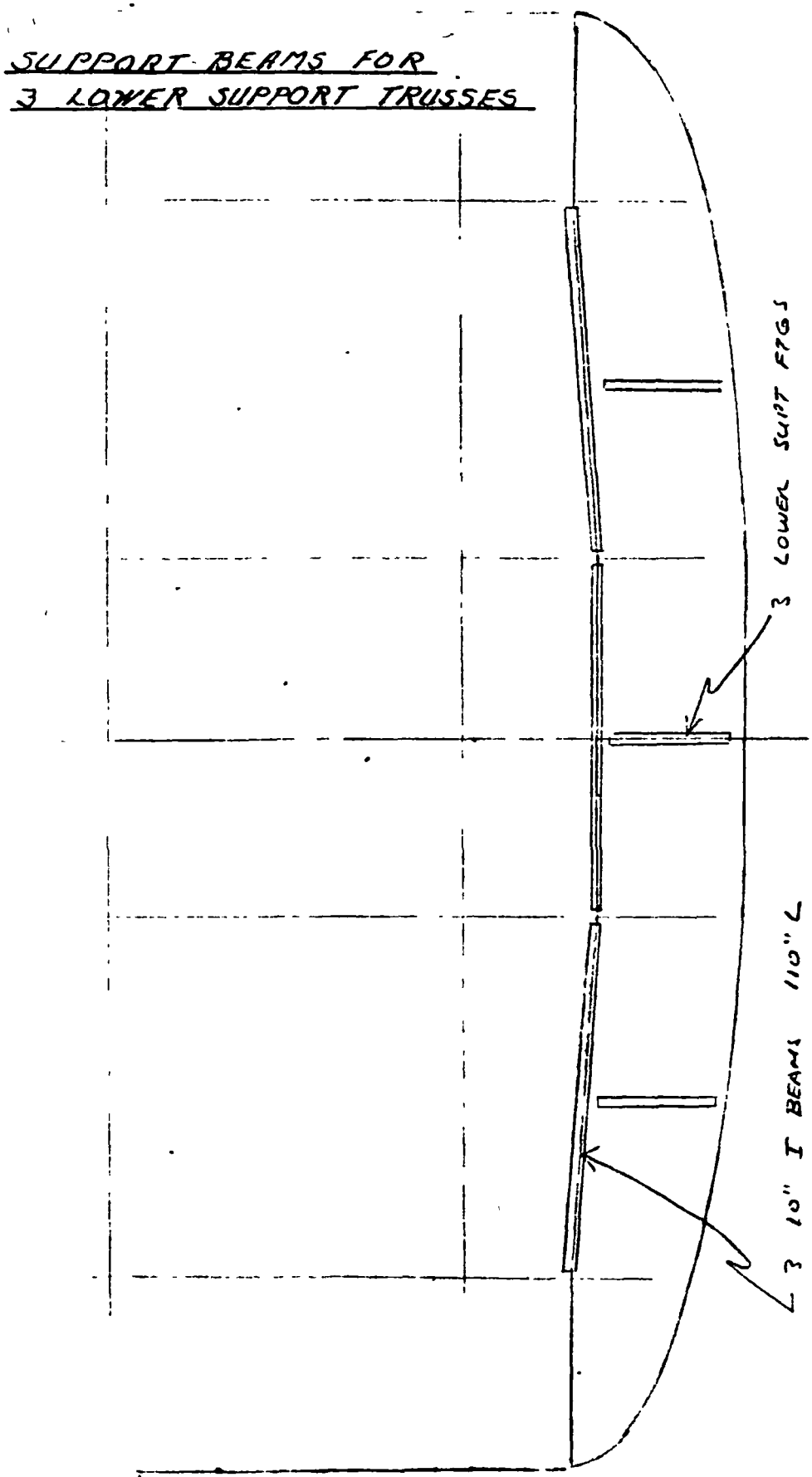
2 REQ'D @ EACH SUPT FITTING
7 PLACES FOR SIDES & TOP
OR 14 REQ

AL TUBE 3½" O.D. ; $t_w = .125$
ℓ L = 85"

WT/EA = $.785\,[(3.5)^2 - (3.25)^2][85][.101]$

WT/EA = 11.4 LBS

WT/14 = 11.4 LBS × 14 = **160 LBS**

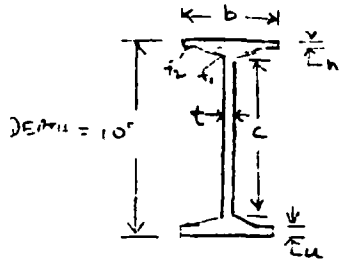

SUPPORT BEAMS FOR
3 LOWER SUPPORT TRUSSES
3 LOWER SUPT FTGS
3 10" I BEAMS 110" L

SUPPORT BEAMS

REQUIRED FOR BOAT TAIL SUPT FITTINGS:

3 REQ'D @ EACH LOWER SUPT FITTING

USE 10" I BEAM, L = 110"



AL EXTRUSION

WT = 8.76 LB/FT OR	0.73 LB/IN
t = 3.10	f_1 = .41
AREA = 7.45 IN^2	f_2 = .19
b = 4660	c = 8
n = 0.31	u = ½

WT/IN = (7.45 IN^2 X .101 LB/IN^3) = .752 LB/IN

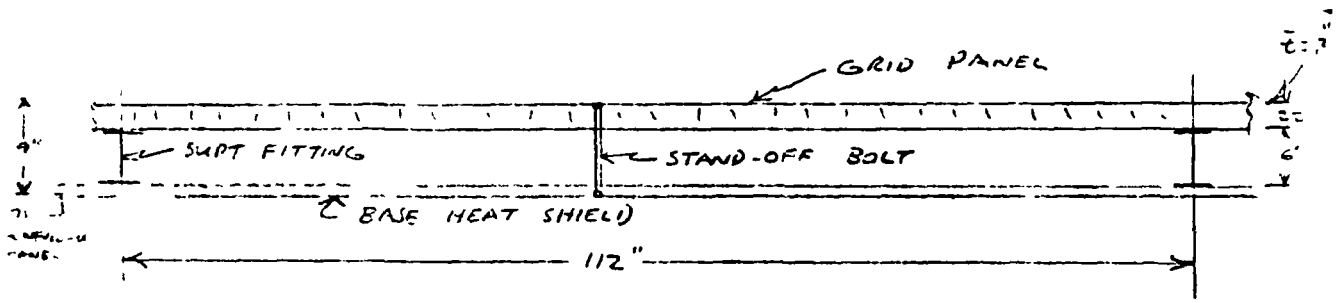
WT/EA = (110 IN X .752 LB/IN) = 82.7 LBS

WT/3 = 82.7 LBS × 3 = **248 LBS**

STAND-OFF BOLTS

REQUIRED BETWEEN BOAT TAIL GRID PANELS AND BASE HEAT SHIELD

REQUIRED BETWEEN STATION 3965 & STATION 3935



EST STAND-OFF BOLTS
½" DIA & 9"L (AL)

PER EACH 112" SECTION
3 REQ IN ONE DIRECTION
& 9 REQ IN OTHER DIRECTION
OR 3 × 9 = 27 REQ PER SECTION

6 112" SECTIONS
REQ'D BOLTS = 27 × 6 OR 162 BOLTS

8 CURVED SECTIONS
REQ'D BOLTS = 27 × 8 OR 216 BOLTS

EST REQ'D STAND-OFF BOLTS = 378 BOLTS

EST WT/BOLT = $.785(.5)^2 \times 9 \times .101$ = .18 LBS/EA

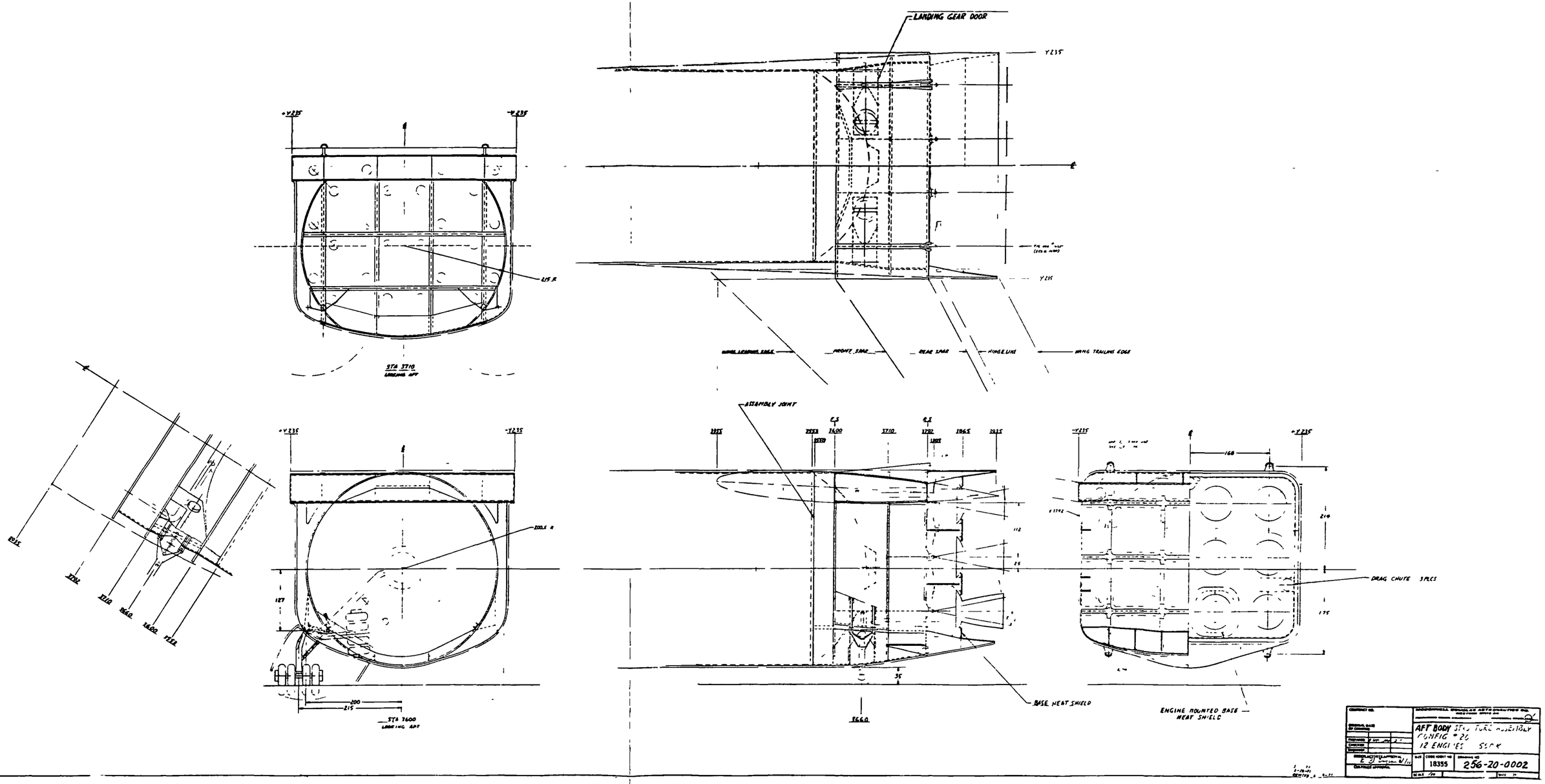
ASSUME BOLT WT .25 LB/EA

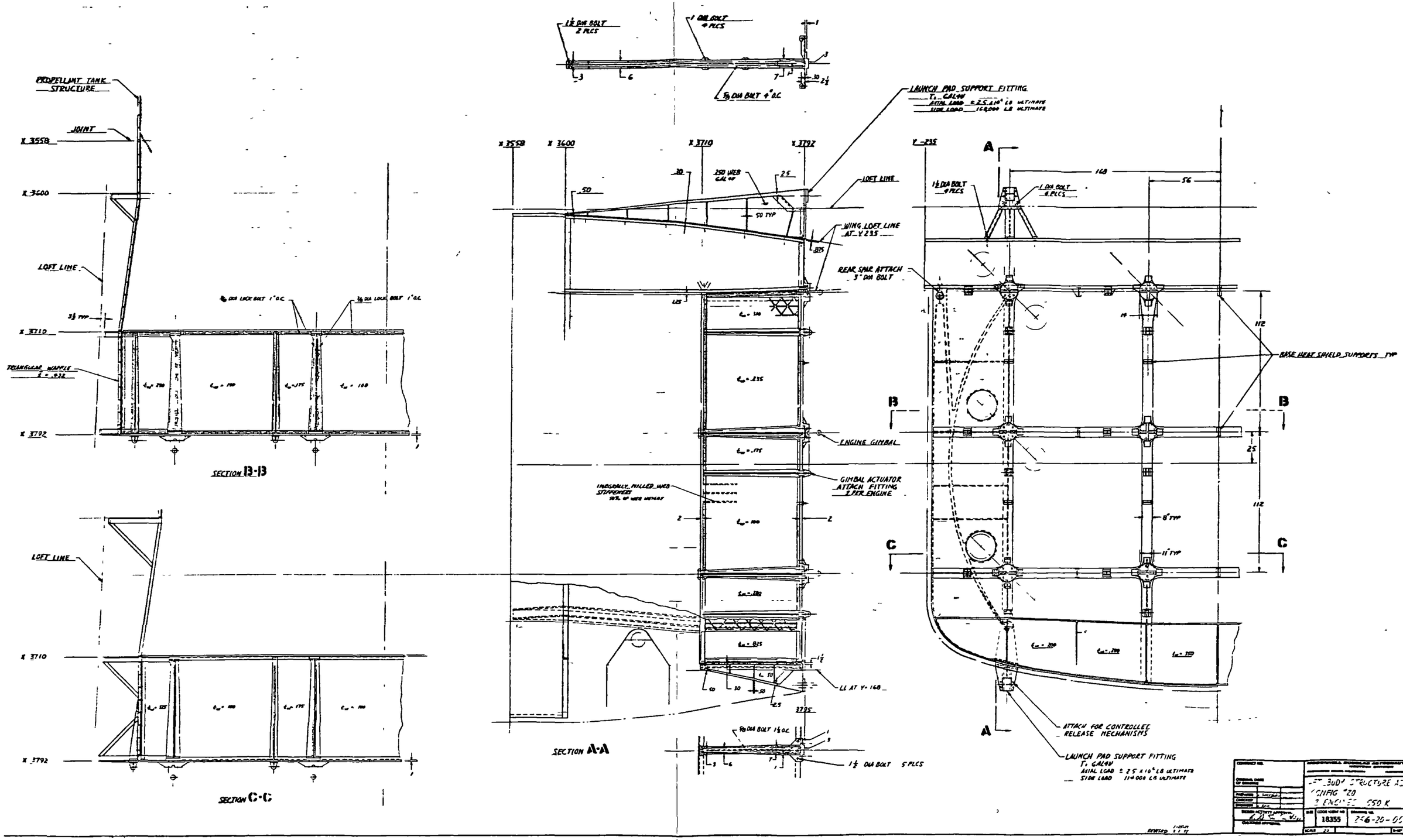
TOTAL WT = (.25 LB) × 378

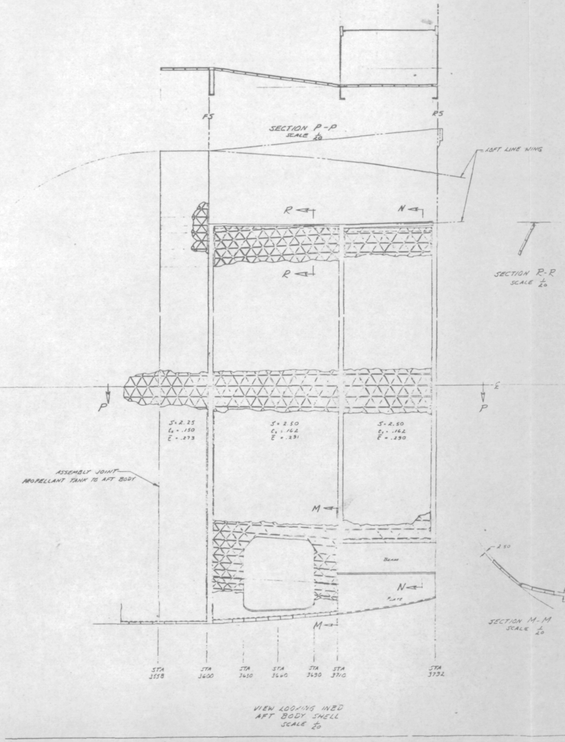
TOTAL WT = 94.5 LBS

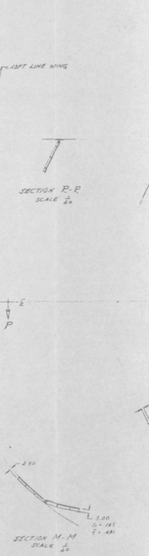
ASSUME **100 LBS**

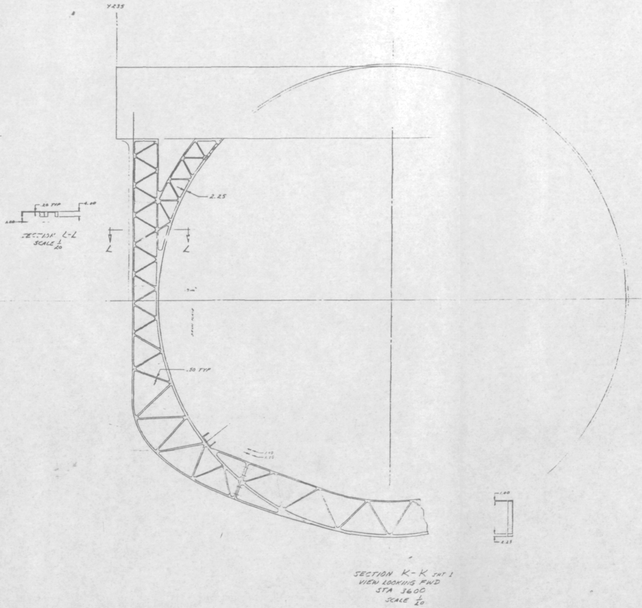
REF R K VEE


LANDING GEAR DOOR
Y235
STA 3710
LOOKING AFT
ASSEMBLY JOINT
BASE HEAT SHIELD
ENGINE MOUNTED BASE HEAT SHIELD
DRAG CHUTE 3 PLCS
STA 3600
LOOKING AFT
AFT BODY
CONFIG #20
12 ENGINES
18355
256-20-0002

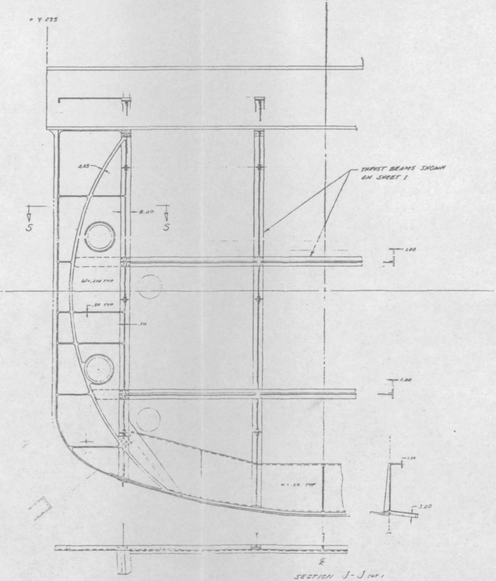

PROPELLANT TANK STRUCTURE
JOINT
X 3558
X 3600
LOFT LINE
X 3710
X 3792
SECTION B-B
SECTION C-C
SECTION A-A
LAUNCH PAD SUPPORT FITTING
LOFT LINE
WING LOFT LINE AT Y 235
REAR SPAR ATTACH 3" DIA BOLT
ENGINE GIMBAL
GIMBAL ACTUATOR ATTACH FITTING 2 PER ENGINE
INTEGRALLY MILLED WEB STIFFENERS
BASE HEAT SHIELD SUPPORTS TYP
ATTACH FOR CONTROLLED RELEASE MECHANISMS
LAUNCH PAD SUPPORT FITTING
AXIAL LOAD ± 2.5 x 10⁶ LB ULTIMATE
SIDE LOAD 114,000 LB ULTIMATE
18355

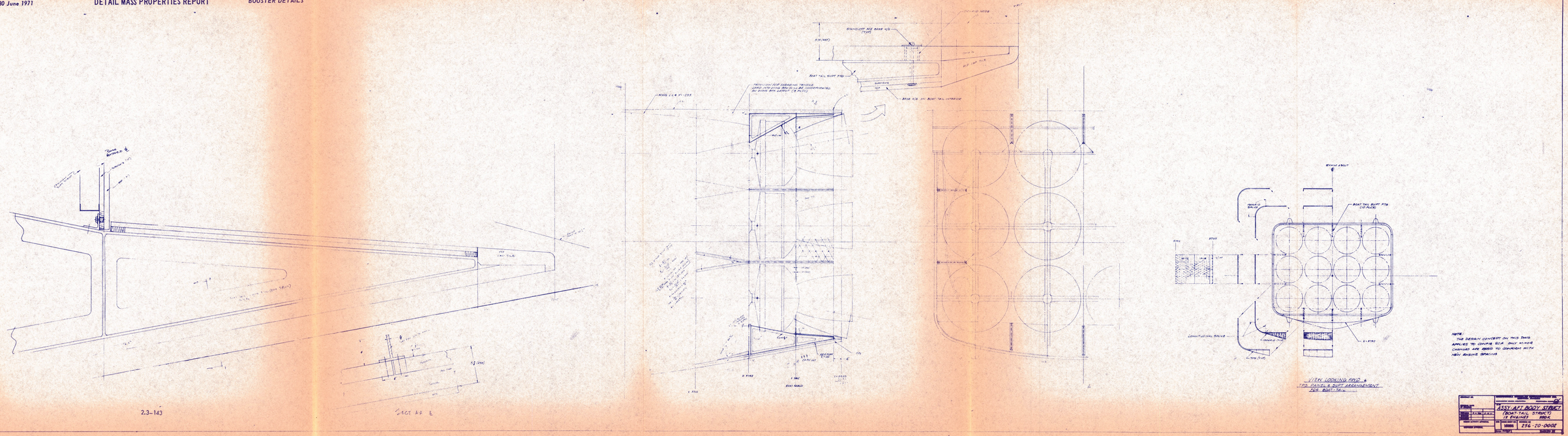

SECTION P-P
SCALE 1/20
LEFT LINE WING
R
N
P
M
ASSEMBLY JOINT PROPELLANT TANK TO AFT BODY
STA 1558
STA 1600
STA 1650
STA 1700
STA 1750
STA 1790
STA 1932
VIEW LOOKING INBD
AFT BODY SHELL
SCALE 1/20


SECTION R-R
SCALE 1/20
SECTION M-M
SCALE 1/20


SECTION L-L
SCALE 1/20
SECTION N-N
SCALE 1/20
SECTION K-K (SHT 1
VIEW LOOKING FWD
STA 1600
SCALE 1/20

SECTION S-S
SCALE 1/20


THRUST BEAMS SHOWN ON SHEET 1
SECTION J-J (SHT 1
VIEW LOOKING FWD
STA 1310
SCALE 1/20


VIEW LOOKING FWD &
TPS PANEL & SUPT ARRANGEMENT
FOR BOAT-TAIL
NOTE:
THE DESIGN CONCEPT ON THIS DWG
APPLIES TO CONFIG 50A. ONLY MINOR
CHANGES ARE REQ'D TO CONFORM WITH
NEW ENGINE SPACING
ASSY-AFT BODY STRUCT
(BOAT-TAIL STRUCT)
12 ENGINES 220K
256-70-0002

REDESIGN OF AFT STRUCTURE

THIS SEGMENT OF THE WEIGHT SUBSTANTIATION PRESENTS A PRELIMINARY ESTIMATE OF THE WEIGHT REDUCTION RESULTING FROM A REDESIGN OF THE AFT SKIRT & THRUST STRUCTURE & THE MAIN GEAR PICK-UP STRUCTURE. THIS REDESIGN IS SHOWN ON DWG. NO. 256-20-0002 AFT BODY STRUCT ASSY - CONFIG 20A, (SEE PAGES 2.3-157 & 2.3-158) AND CONSISTS PRIMARILY OF THE FOLLOWING:

1. CHANGE IN ASCENT ENGINE SPACING FROM 112" TO 106"
2. REDESIGN OF MAIN GEAR PICK-UP STRUCTURE. THIS REDESIGN ELIMINATED THE CENTER TIE RODS & TORQUE BOX PANELS & INTEGRATED THE AFT TRUSS INTO THE EXISTING FRAME AT STA. 3710
3. REDESIGN OF FRAMES AT STATIONS 3000, 3710, AND 3792.

THE PRELIMINARY SIZING DETAIL SHOWN ON THIS SIZING HAS NOT BEEN VERIFIED BY A DETAIL STRESS ANALYSIS. HOWEVER, THIS INFORMATION WAS USED FOR THE DETAIL WEIGHT CALCULATIONS SHOWN ON PAGES 2.3-146 THRU 2.3-156 FOR THE AFT SKIRT, FITTINGS & THE FRAMES AT STATIONS 3000, 3710 & 3792

THE WEIGHT TABLE SHOWN ON THE FOLLOWING PAGE SUMMARIZES THE WEIGHT DIFFERENCES BETWEEN THE AFT SKIRT & THRUST STRUCTURE OF THE MAIN GEAR PICK-UP STA. FOR CONFIGURATIONS 20 & 20A. A MORE PRIMARY WEIGHT SUBSTANTIATION FOR ALL OF THESE ITEMS IS SHOWN ON PAGES 2.3-146 THRU 2.3-156

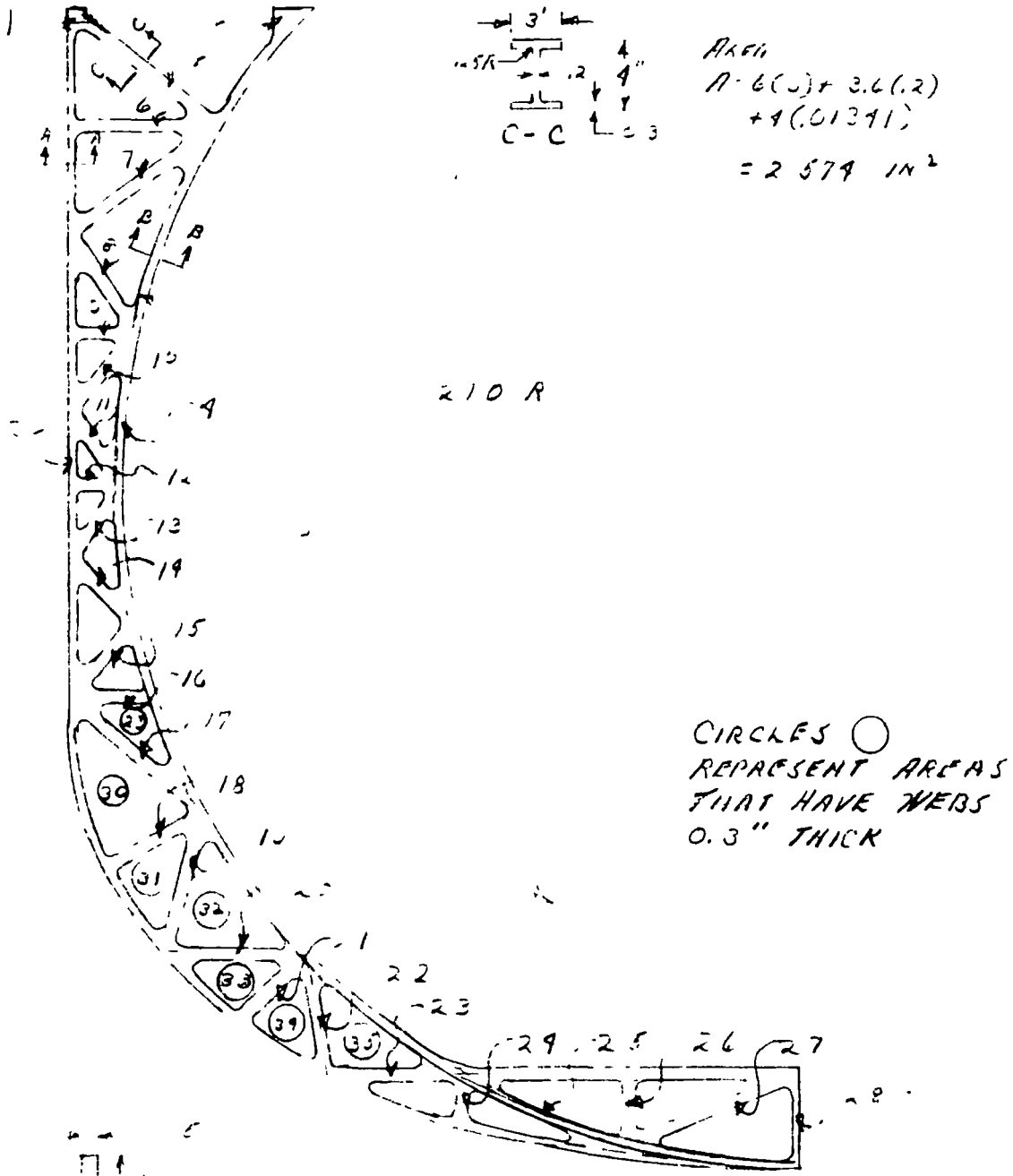
	[illegible]	[illegible]
AFT SKIRT & THRUST STRUCTURE		
SIDEWALL STA 3609 -3710	4,244	4,170
SIDEWALL STA 3710 - 3788	2,851	[illegible]
FRAME STA. 3600 (LESS BRACES)	2,550	1,735
FRAME STA 3710 (LESS BRACES)	3,660	1,905 *
FRAME STA 3752 (LESS BRACES)	4,495	1,815
INBOARD BEAMS & WEB	8,360	[illegible],130
UPPER LAUNCH FITTINGS	1,580	1,475
LOWER LAUNCH FITTINGS	692	540
AFT TAIL ISOGRID PANELS	2,999	2,780
CONTINGENCY - 10 %	--	[illegible]
TOTAL	31,811	30,795
Δ WT	-1,016 LB	
MAIN GEAR PICK-UP		
TRUSS UPPER HALF - STA 3635	761	--
TRUSS LOWER HALF - STA. 3635	548	--
TRUSS CENTER - STA. 3660	438	--
TRUSS UPPER HALF - STA 3685	703	--
TRUSS LOWER HALF STA 3685	622	--
INTERCOSTALS	428	--
TRUSS SUPPORT PANELS	896	--
TRUSS PANEL SUPPORT ANGLES	37	--
UPPER MAIN GEAR PICK-UP	--	950
LOWER MAIN GEAR PICK-UP	--	522
CONTINGENCY - 10 %	454	147
TOTAL	4,996	1,619
Δ WT	-3,377 LB	

TOTAL WEIGHT DIFFERENCE -4,393 LB

* INCLUDES AFT MAIN GEAR PICK-UP PROVISIONS

FRAME - FR 3600

MATERIAL: 7075-T7351



FRAME STA 3600

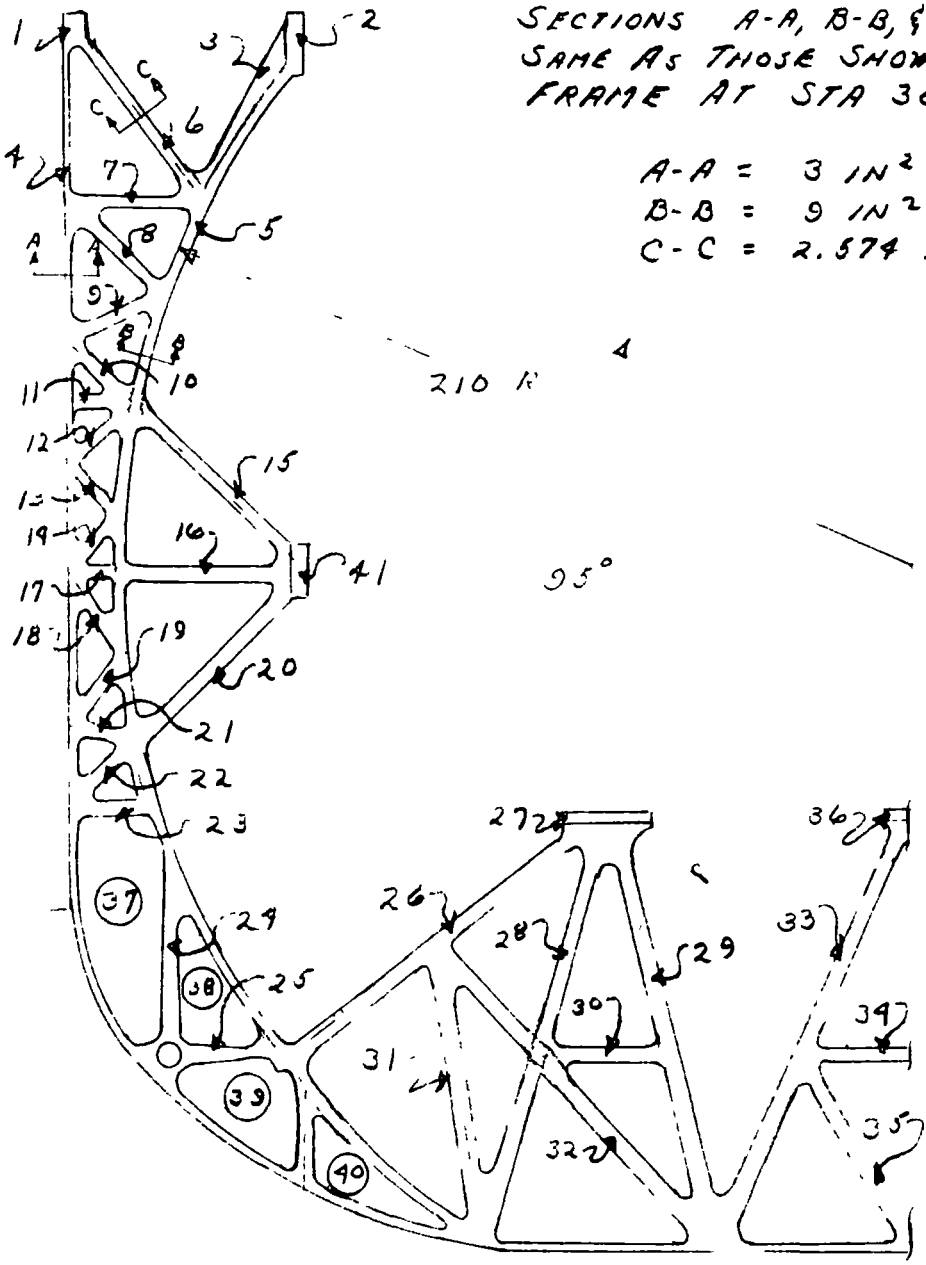
VOLUMES:

1	$V = 5(4)(4)$	=	80	IN^3
2	$V = 4(5)5)$	=	100	IN^3
3	$V = 480(3)$	=	1,490	IN^3
4	$V = 2\pi(210)\left(\frac{22}{360}\right)(9)$	=	3,260	IN^3
5	$V = 46(2.574)$	=	118	IN^3
6	$V = 40(2.574)$	=	103	IN^3
7	$V = 51(2.574)$	=	131	IN^3
8	$V = 34(2.574)$	=	88	IN^3
9	$V = 17(2.574)$	=	44	IN^3
10	$V = 27(2.574)$	=	70	IN^3
11	$V = 24(2.574)$	=	62	IN^3
12	$V = 13(2.574)$	=	33	IN^3
13	$V = 21(2.574)$	=	54	IN^3
14	$V = 22(2.574)$	=	57	IN^3
15	$V = 26(2.574)$	=	67	IN^3
16	$V = 23(2.574)$	=	59	IN^3
17	$V = 48(2.574)$	=	123	IN^3
18	$V = 31(2.574)$	=	80	IN^3
19	$V = 39(2.574)$	=	100	IN^3
20	$V = 39(2.574)$	=	100	IN^3
21	$V = 25(2.574)$	=	64	IN^3
22	$V = 32(2.574)$	=	82	IN^3
23	$V = 139(2.574)$	=	358	IN^3
24	$V = 15(2.574)$	=	39	IN^3
25	$V = 110(9)$	=	990	IN^3
26	$V = 22(2.574)$	=	57	IN^3
27	$V = 57(2.574)$	=	147	IN^3
28	$V = 28(1.287)$	=	36	IN^3
29	$V = 13(11)(.3)$	=	43	IN^3
30	$V = 15(40)(.3)$	=	180	IN^3
31	$V = 11(22)(.3)$	=	73	IN^3
32	$V = 12(32)(.3)$ } WEB	=	115	IN^3
33	$V = 14(15)(.3)$	=	63	IN^3
34	$V = 12(20)(.3)$	=	72	IN^3
35	$V = 20(18)(.3)$	=	108	IN^3
	TOTAL VOLUME/SIDE		8596	IN^3

TOTAL FRAME WT = $2(8,596(.101)) =$ **1,735 LB**

FRAME STA 3710

MATERIAL: 7075 - T7351



SECTIONS A-A, B-B, & C-C ARE THE SAME AS THOSE SHOWN FOR THE FRAME AT STA 3600

A-A = 3 IN²
B-B = 9 IN²
C-C = 2.574 IN²

CIRCLES ◯ REPRESENT AREAS THAT HAVE WEBS 0.3" THICK

SCALE 1/50

FRAME STA 3710

VOLUMES:

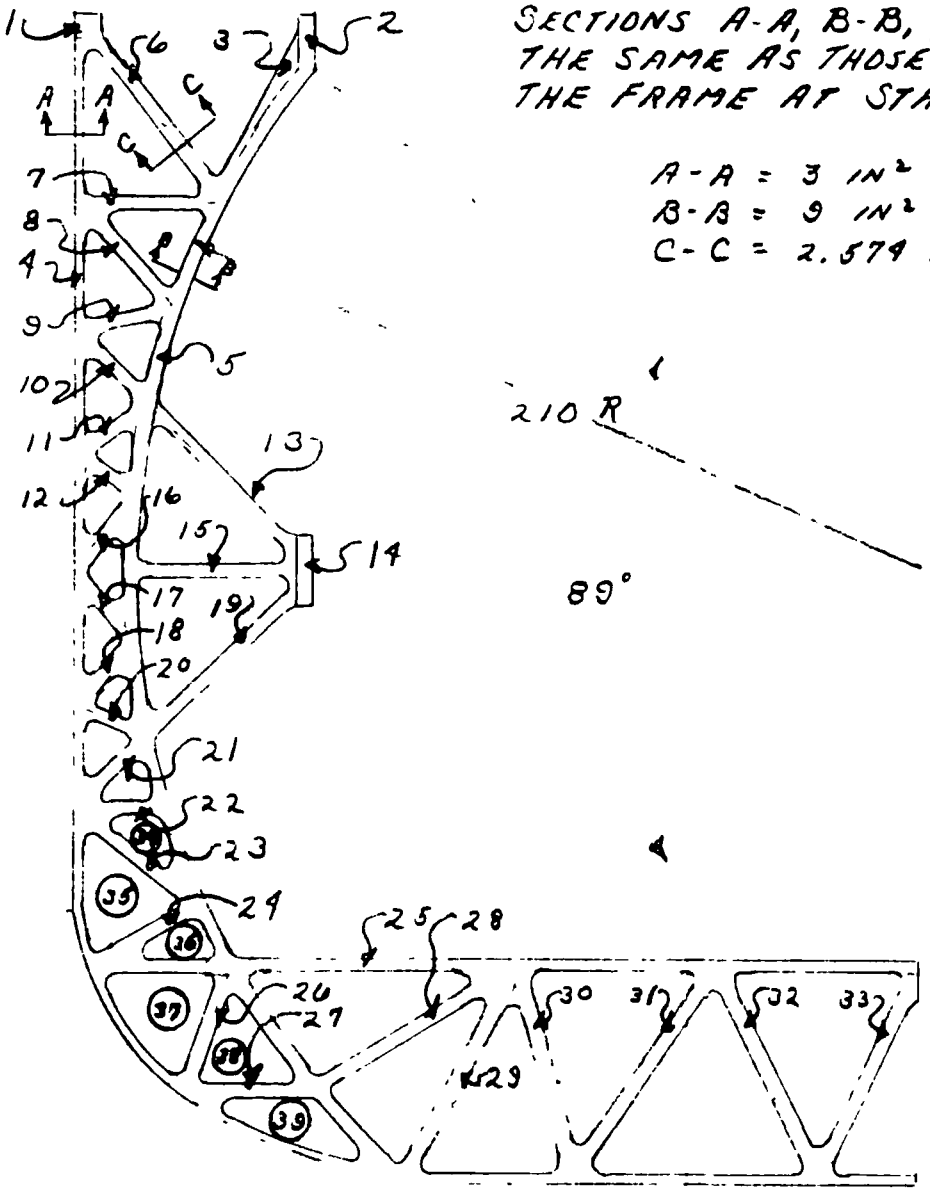
		IN^3
1	$V = 5(4)(4) =$	80
2	$V = 4(9)(16) =$	256
3	$V = 4(43)(1) =$	172
4	$V = 495(3) =$	1,485
5	$V = 2\pi(210)\left(\frac{25}{360}\right)9 =$	3,130
6	$V = 54(2.574) =$	139
7	$V = 35(2.574) =$	90
8	$V = 34(2.574) =$	88
9	$V = 28(2.574) =$	72
10	$V = 22(2.574) =$	57
11	$V = 16(2.574) =$	41
12	$V = 20(2.574) =$	52
13	$V = 18(2.574) =$	46
14	$V = 18(2.574) =$	46
15	$V = 56(2.574) =$	144
16	$V = 44(2.574) =$	113
17	$V = 17(2.574) =$	44
18	$V = 23(2.574) =$	59
19	$V = 23(2.574) =$	59
20	$V = 56(2.574) =$	144
21	$V = 16(2.574) =$	41
22	$V = 21(2.574) =$	54
23	$V = 20(2.574) =$	52
24	$V = 70(2.574) =$	180
25	$V = 42(2.574) =$	108
26	$V = 100(2.574) =$	257
27	$V = 24(4)(25) =$	240
28	$V = 114(2.574) =$	294
29	$V = 114(2.574) =$	294
30	$V = 31(2.574) =$	80
31	$V = 79(2.574) =$	203
32	$V = 108(2.574) =$	278
33	$V = 121(2.574) =$	312
34	$V = 27(2.574) =$	70
35	$V = 58(2.574) =$	149
36	$V = 7(4)(2.5) =$	70
37	$V = 22(60)(.3) =$	396
38	$V = 12(35)(3) =$	126
39	$V = 15(32)(.3) =$	144
40	$V = 23(15)(.3) =$	104
41	$V = 14(4)4 =$	112

TOTAL VOLUME/SIDE 9,881 IN^3

TOTAL FRAME WT = $2(9,881)(.101) =$ **1,995 LB**

FRAME STA 3792

MATERIAL : 7075 - T7351



SECTIONS A-A, B-B, & C-C ARE THE SAME AS THOSE SHOWN FOR THE FRAME AT STA 3600

A-A = 3 IN²
B-B = 9 IN²
C-C = 2.574 IN²

CIRCLES ○ REPRESENT AREAS THAT HAVE WEBS 0.3 " THICK

FRAME STA 3792

	VOLUMES:	IN³
1	V = 5(4)(4) =	80
2	V = 4(4)(16) =	256
3	V = 4(43)(1) =	172
4	V = 487 (3) =	1,460
5	V = 2π(210)(82/360) 9 =	2,940
6	V = 55(2.574) =	142
7	V = 36(2.574) =	93
8	V = 38(2.574) =	98
9	V = 26(2.574) =	67
10	V = 24(2.574) =	62
11	V = 23(2.574) =	59
12	V = 18(2.574) =	97
13	V = 54(2.574) =	139
14	V = 18(9)(9) =	288
15	V = 93(2.574) =	111
16	V = 22(2.574) =	57
17	V = 20(2.574 =	52
18	V = 20(2.574) =	52
19	V = 54(2.574) =	139
20	V = 19(2.574) =	49
21	V = 23(2.574) =	59
22	V = 22(2.574) =	57
23	V = 40(2.574) =	103
24	V = 32(2.574) =	83
25	V = 220(2.574) =	567
26	V = 35(2.574) =	90
27	V = 35(2.574) =	90
28	V = 60(2.574) =	155
29	V = 62(2.574) =	160
30	V = 57(2.574) =	147
31	V = 70(2.574) =	180
32	V = 62(2.574) =	160
33	V = 62(2.574) =	160
34	V = 12(12)(.3) =	43
35	V = 17(28)(.3) =	143
36	V = 12(12)(.3) =	43
37	V = 17(28)(.3) =	143
38	V = 15(26)(.3) =	117
39	V = 21(14)(.3) =	89

TOTAL VOLUME/SIDE 8,952 IN³

TOTAL FRAME WT = 2(8,952)(.101) = **1,810 LB**

SIDEWALL - STA 3604 - 3710

AVERAGE DIAMETER:
WAS: 410"
IS : 404"

NEW WT = $\frac{404}{410}$ (4,244) = **4,170 LB**

SIDEWALL - STA 3714 - 3788

AVERAGE DIAMETER.
WAS: 224"
IS : 214"

NEW WT = $\frac{214}{224}$ (2,891) = **2,760 LB**

INBOARD BEAMS & WEB
OUTBOARD VERTICAL CAPS

THE OUTBOARD VERTICAL BEAM CAPS AT STATIONS 3710 AND 3792 WERE INTEGRAL WITH THE FRAMES ON CONFIGURATION 20 SO THEY MUST BE ADDED IN FOR CONFIGURATION 20A

BASED ON CONFIGURATION 20, CAP WT = 1.73 LB/IN

STA 3710 - CAP LENGTH = 311" 2 REQ
STA 3792 CAP LENGTH = 303" 2 REQ

TOTAL WT OUTBOARD VERTICAL BEAMS

WT = 2 (311 + 303)(1.73) = 2,120 LB

NEW WT FOR INBOARD BEAMS & WEB:

WT = 8,660 + 2,120 = **10,780 LB**

UPPER LAUNCH FITTINGS

ULTIMATE COMPRESSIVE LOAD:
WAS 2.5 X10^6 LB
IS : 2.257 X10^6 LB

NEW WT = $\frac{2.257}{2.5}$ (1,580) = **1,425 LB**

LOWER LAUNCH FITTINGS

ULTIMATE COMPRESSIVE LOAD :
WAS : 2.5×10^6 LB
IS : 1.952×10^6 LB

$$\text{NEW WT} = \frac{1.952}{2.5}(692) = \boxed{540 \text{ LB}}$$

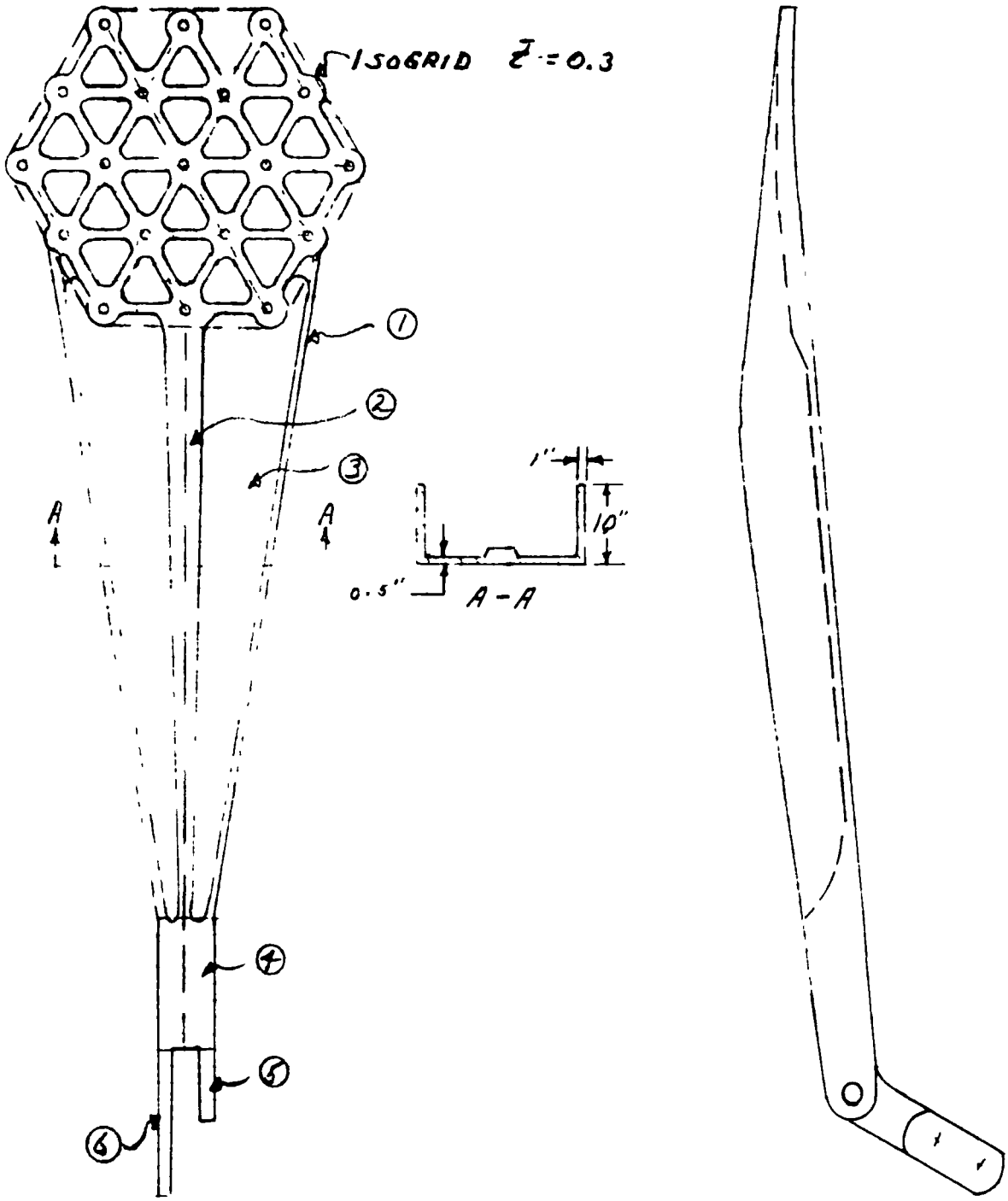
BOAT TAIL EXTERIOR ISOGRID PANELS

AVERAGE CIRCUMFERENCE :
WAS : 1,584"
IS : 1,474"

$$\text{NEW WT} = \frac{1,474}{1,584}(2,099) = \boxed{2,780 \text{ LB}}$$

UPPER MAIN GEAR PICK-UP FITTING - 2 REQ

LOCATED @ STA 3690
MATERIAL : 7075 - T7351



SCALE $\frac{1}{20}$

UPPER MAIN GEAR PICK-UP FITTING - 2 REQ

AREA ENCLOSED BY DASHED LINE EQUIVALENT TO AN ISOGRID STRUCTURE WITH A t OF 0.30"

AREA = 32(39) = 1,250 IN²

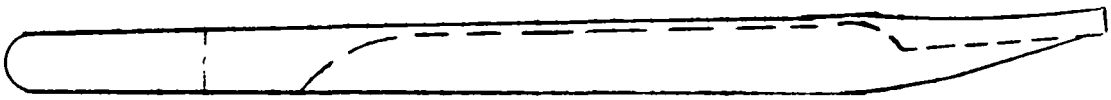
VOLUME:

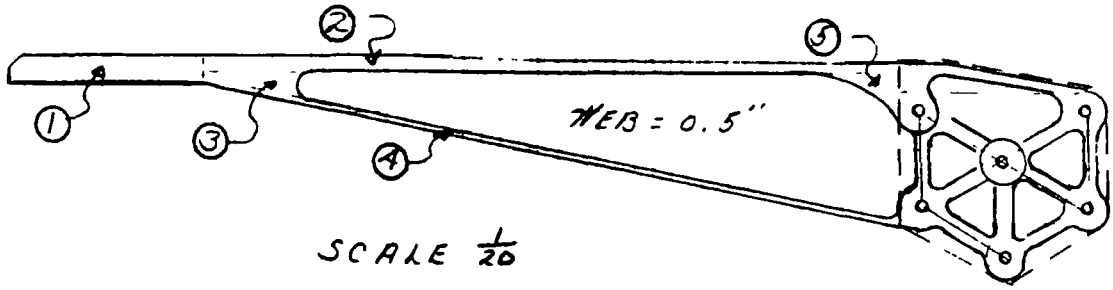
VOL ISOGRID = 1250(.3) =	376	IN³
VOL ① = 2[83(1)(7.5+19)/2] =	1450	IN³
VOL ② = 2[72((2+1)/2)2] =	432	IN³
VOL ③ = 2[75((4.2)/2)(.5)] =	450	IN³
VOL ④ = 2[16(3.5)7] =	785	IN³
VOL ⑤ = 8.5(2)6.5) =	110	IN³
VOL ⑥ = 25(2)(6.5) =	325	IN³
TOTAL VOLUME/SIDE	3,928	IN³
WEIGHT OF FITTING = VP = 3,928(.101) =	397	LB
ATTACH PLUGS - WT = 19(4.1)* =	78	LB
TOTAL WT/SIDE =	475	LB
TOTAL WT FOR BOTH SIDES =	950	LB

* SEE DETAIL WEIGHT CALCULATIONS FOR ATTACH PLUGS IN THE WEIGHT SUBSTANTIATION FOR THE WING LEADING EDGE ATTACH

LOWER MAIN GEAR PICKUP FITTING - 2 REQ

LOCATED @ STA 3690
MATERIAL: 7075 - T7351





AREA ENCLOSED BY DASHED LINE EQUIVALENT TO AN ISOGRID STRUCTURE WITH A $\bar{t}$ OF 0.30"

$$AREA = 21(3) + 21(14) + \left(\frac{21}{2}\right)(6.5) = 426\ IN^2$$

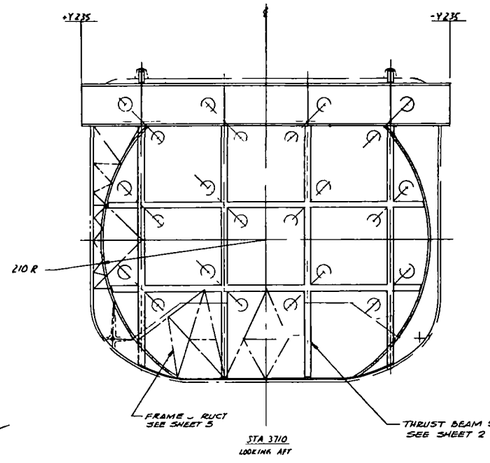
VOLUME:

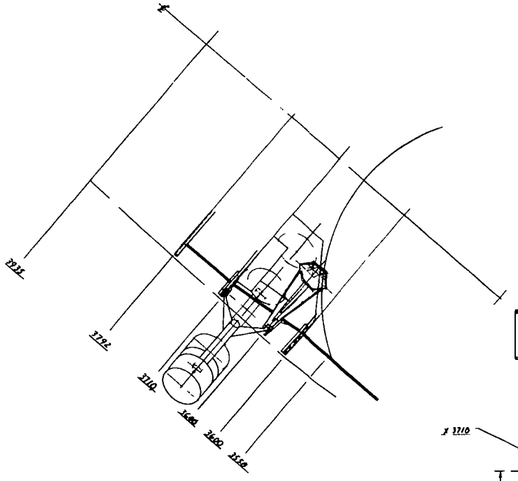
VOL /ISOGRID = $426(.3)$	=	128 IN^3
VOL ① = $20.5(3)(6.5)$	=	400 IN^3
VOL ② = $\left(\frac{21}{2}\right)(73.3)\left(\frac{6.5+8}{2}\right)$	=	795 IN^3
VOL ③ = $11\left(\frac{3}{2}\right)7$	=	116 IN^3
VOL ④ = $76(1)\left(\frac{6.5+8}{2}\right)$	=	550 IN^3
VOL ⑤ = $7\left(\frac{1.5}{2}\right)(8)$	=	126 IN^3
WEB = $63\left(\frac{19}{2}\right)(.5)$	=	220 IN^3
TOTAL VOLUME =		2,335 IN^3

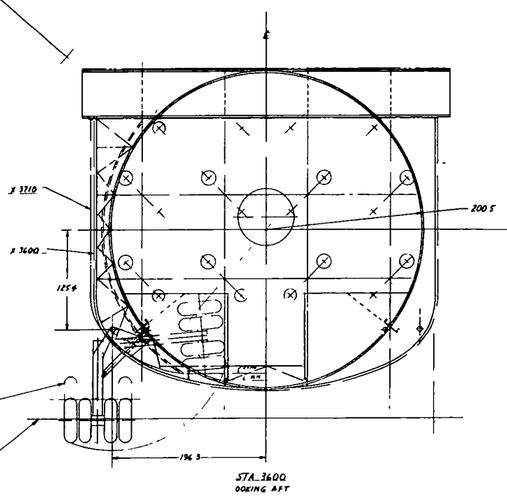
WEIGHT OF FITTING = VT = 2,335(.101) = 236 LB
ATTACH PLUGS - WT = 6(4.1)* = 26 LB
TOTAL WT / SIDE = 261 LB

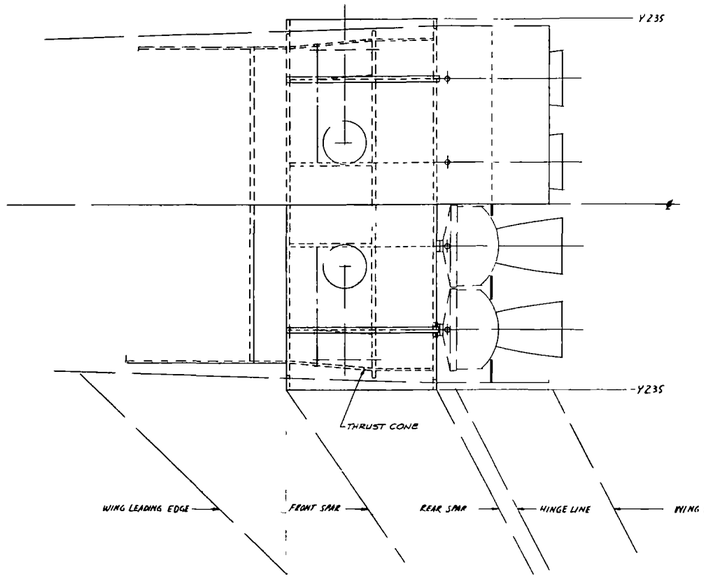
TOTAL FOR BOTH SIDES = **522 LB**

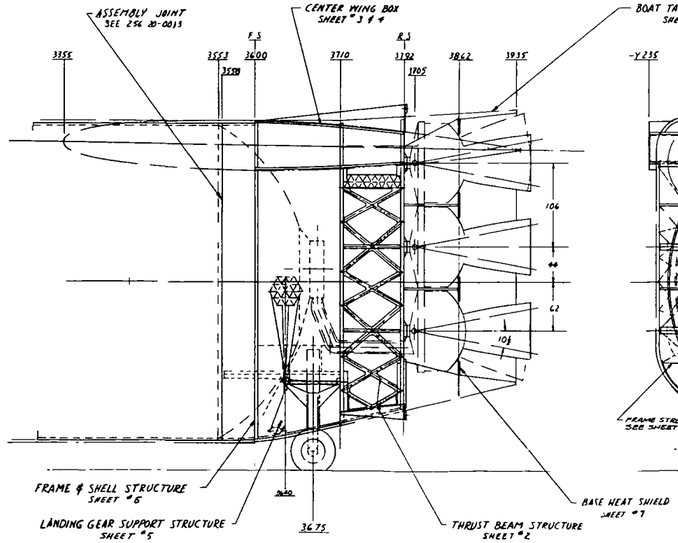
* FOR WEIGHT OF ATTACH PLUGS, SEE DETAIL CALCULATIONS IN WING LEADING EDGE ATTACH

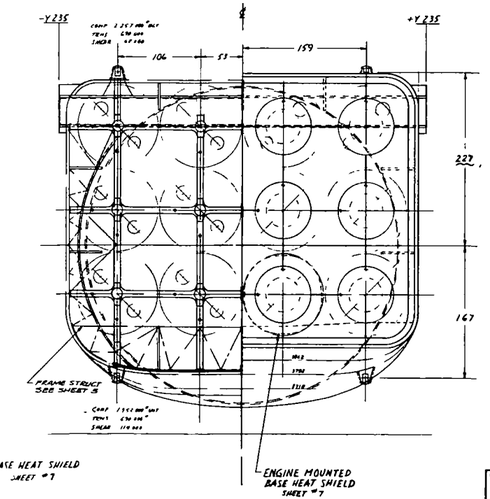






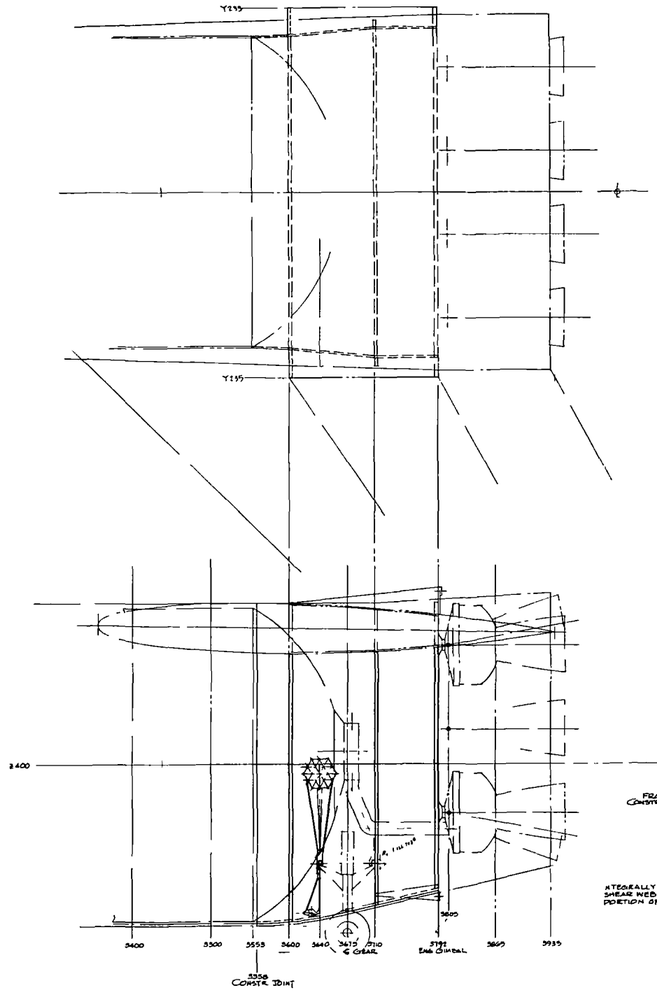


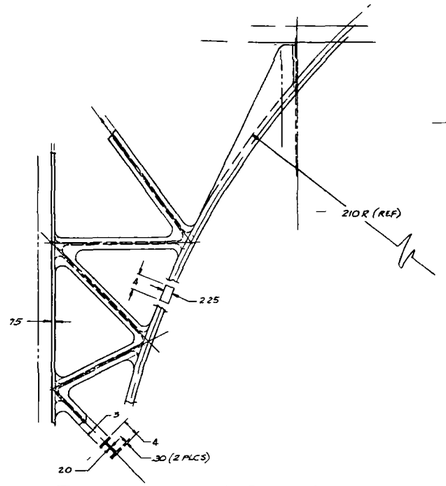




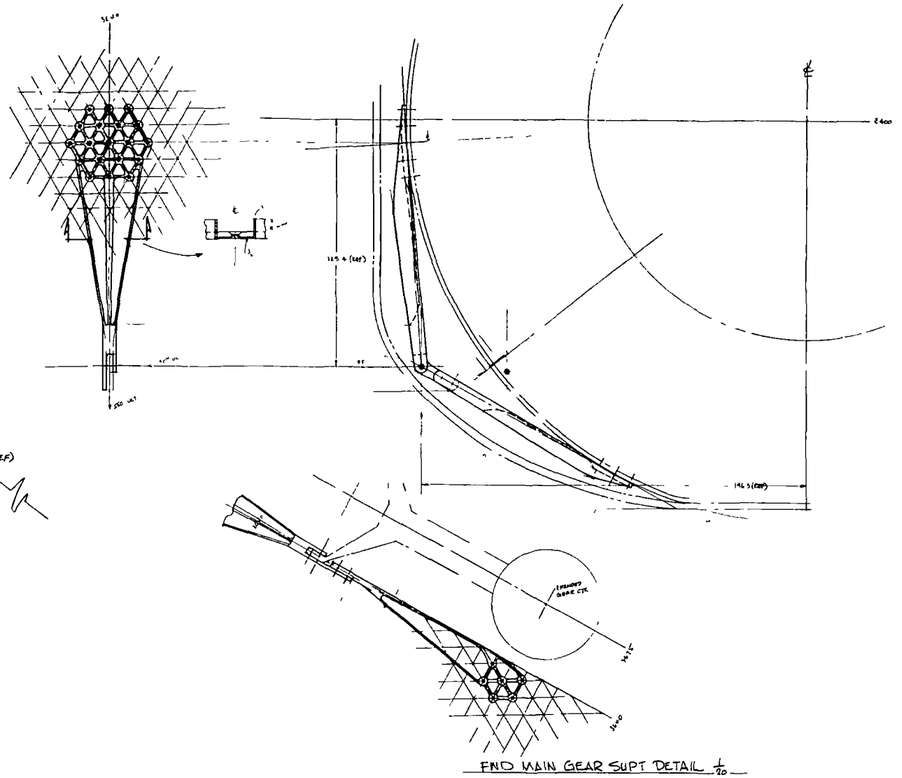
REVISED 6-2-71

CONTRACT NO	MCDONNELL DOUGLAS ASTRONAUTICS CO. EASTERN DIVISION
ORIGINAL DATE OF DRAWING	
PREPARED	
CHECKED	
ENGINEER	
DESIGN ACTIVITY APPROVAL	AFT BODY STRUCTURE ASSEMBLY CONFIG #20A 12 ENGINES 550K
CUSTOMER APPROVAL	SIZE: — CODE IDENT NO: 18355 — DRAWING NO: 256-20-0002 — SCALE 1/10 — SHEET 1 OF 7

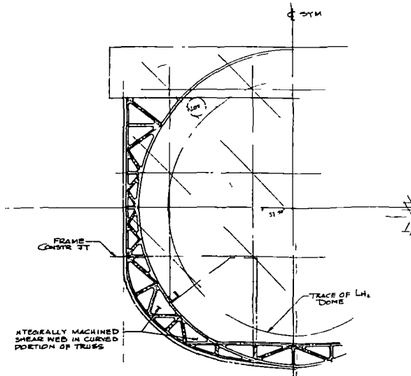




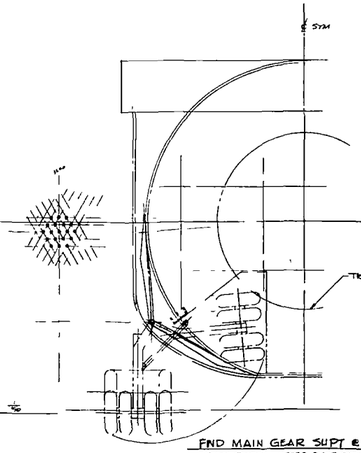
PRELIMINARY SIZING DETAIL ½
FOR FRAME TRUSSES @ 3600, 3710 & 3792



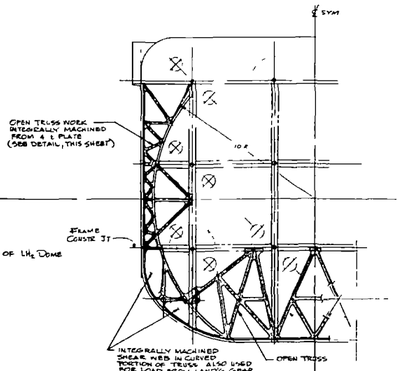
FWD MAIN GEAR SUPT DETAIL 1/20



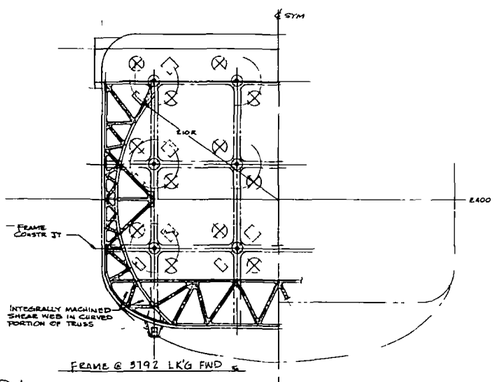
FRAME @ 3600 LK'G FWD ½



FWD MAIN GEAR SUPT @ 3640 LK'G FWD ½
(SEE DETAIL UPPER RIGHT CORNER, THIS SHEET)



FRAME @ 3710 LK'G FWD &
AFT MAIN GEAR SUPPORT FR.



FRAME @ 3792 LK'G FWD

CONTRACT NO
ORIGINAL DATE OF DRAWING
PREPARED
CHECKED
ENGINEER
DESIGN ACTIVITY APPROVAL
DISTRICT APPROVAL

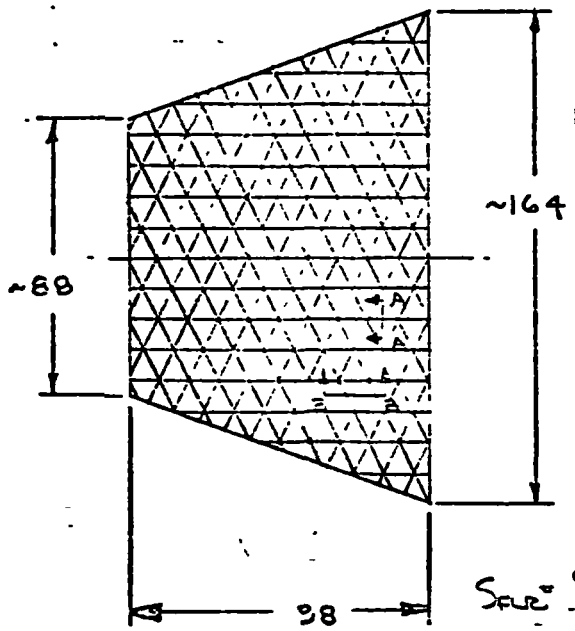
AFT BODY STRUCT ASSY
CONFIG 20A
FRAMES & SHELL STRUCT

SIZE
CODE IDENT NO 18355
DRAWING NO 256-20 -0002
SCALE
SHEET

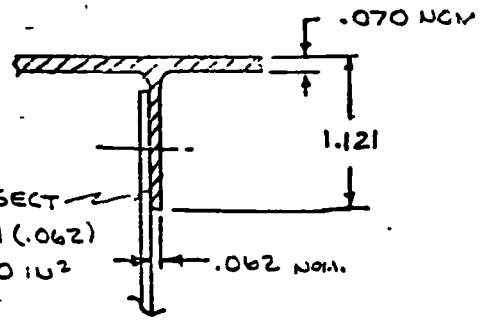
WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
⑦ CREW COMPARTMENT		[1920]
FLOOR	160 & 161	(429)
UPPER PANEL (ISOGRID)	161	167
LOWER PANEL (ISOGRID)	161	122
CORE (TRUSS)	161	109
SIDEWALL ATTACH ANGLES	161	35
MISCELLANEOUS & ATTACH PARTS	161	21
AFT PRESSURE BULKHEAD	162 & 163	(490)
FWD PANEL (ISOGRID)	162	130
AFT PANEL (ISOGRID)	162	100
CORE (TRUSS)	162	72
SIDEWALL & FLOOR ATTACH ANGLES	163	31
ACCESS DOOR	163	97
MISCELLANEOUS & ATTACH PARTS	163	19
FWD INTERMEDIATE BULKHEAD	163 & 164	(65)
ISOGRID PANEL	164	42
SIDEWALL & FLOOR ATTACH ANGLES	164	13
MISCELLANEOUS & ATTACH PARTS	164	4
LONGITUDINAL PRESSURE PANELS	165 & 166	(78)
STIFFENED PANEL - LEFT HALF	165	19
STIFFENED PANEL - RIGHT HALF	165	34
SIDEWALL FORMERS	165	9
ATTACH ANGLES (STA 1060 & 1140)	165	2
SIDEWALL & FLOOR ATTACH ANGLES	165	10
MISCELLANEOUS & ATTACH PARTS	165	4
CREW DOOR & JAMB	166	(176)
COCKPIT ENCLOSURE	166 & 167	(752)
WINDSHIELD INSTALLATION	166	450
WINDSHIELD THERMAL PROTECTION	167	302

COCKPIT FLOOR

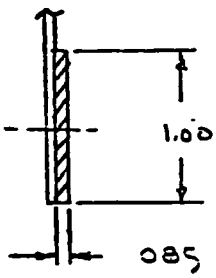


$P_{DESIGN} = 2.0(10.9)$
$= 21.8$ PSIA (ULT)

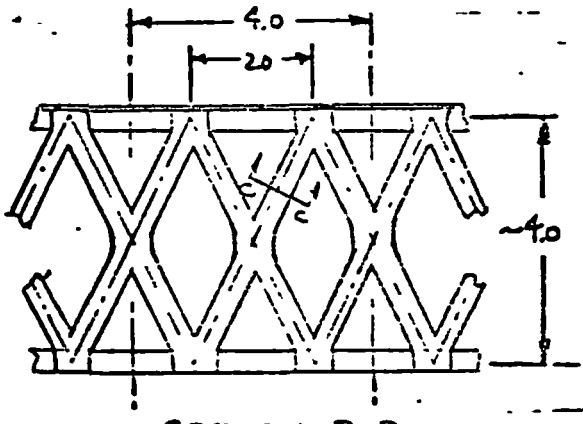


X-SECT
$= 1.121(.062)$
$= .070\ IN^2$

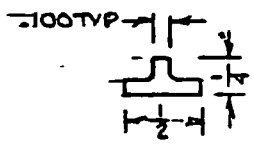
$S_{FLR} = \frac{98(126)}{144}$
$= 85.75\ FT^2$



SECTION A-A
X-SECT = $.085\ IN^2$



SECTION B-B



SECTION C-C
AVERAGE X-SECT
$= .65(.1) = .065\ IN^2$

FACE & CORE GEOMETRY / "H.B. MATHEWS" - STRUCT

WEIGHT:

UPPER FACE

$\alpha = \frac{bcl}{th} = \frac{.062(1051)}{.070(4)(.866)} = .269$

$I = t(1+3\alpha) = .070(1.807) = .127$

WT = 85.75(144)(.0127) = 156.8

LWR FACE

$I = 3\frac{bd}{h} = \frac{3(.085)(1)}{4(.866)} = .074$

WT = 12348(.0074) = 91.4

CORE

$I = \frac{2(4)(1.12)(.065)}{2(4)(.866)} = .084$

WT = 12348(.0084) = 103.7

FLAT - S.W ATT. (ASSUME $1\frac{1}{2} \times \frac{3}{16}$ SOLID BORDER UPPER & LOWER FACES)

WT = 1.5(466)(.0188+.0118) = 21.4 *

S.W & BULKHEAD ATT. ANGLES (ASSUME $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{8}$ UPPER & LWR ATT. ANGLES.

WT = 3(466)(.0125)(2) = 35.0

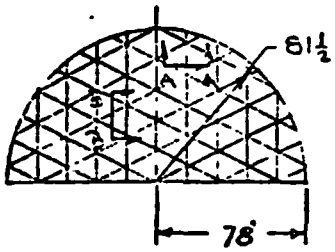
ATTACH & MISC 5%

WT = 408.3 x .05 = 20.7

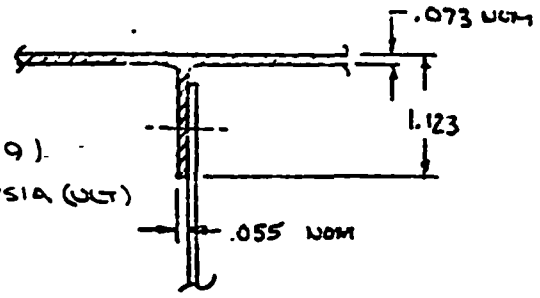
COCKPIT FLOOR (TOTAL) 429.0#

IN FLOOR SUMMARY, 10 LB OF ATTACH PENALTY INCLUDED IN UPPER FACE WT & 11 LB IN LOWER FACE

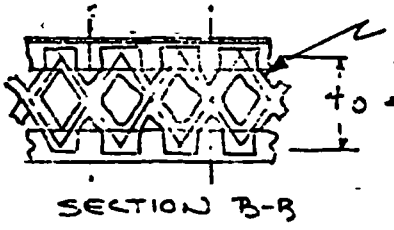
AFT PRESS. BULKHEAD



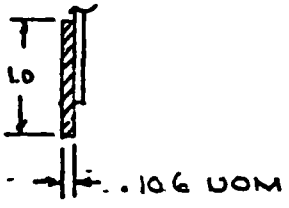
P_{DES} = 2.0 (10.9)
= 21.8 PSIA (ULT)



$$S = \frac{\pi R^2}{2} = \frac{3.14(78)^2}{2} + 250$$
$$= 9802\ IN^2 = 68.1\ FT^2$$



SECTION B-B



SECTION A-A

WEIGHTS:

FWD FACE

$$\alpha = \frac{bd}{th} = \frac{.055(1.05)}{.073(3.464)} = .228$$

$$I = t(1+3\alpha) = .073\ (1.684) = .123$$

WT = 9802 (.0123) = 120.6

AFT FACE

$$I = 3\frac{bd}{n} = \frac{3(.106)(1)}{4(.866)} = .092$$

WT = 9802 (.0092) = 90.2

CORE

$$I = \frac{2(4)(1.12)(.058)}{2(4)(.866)} = .075$$

WT = 9802 (.0075) 73.5

FLAT - S.W. ATT. (ASSUME $1\frac{1}{2} \times \frac{3}{16}$ SOLID)
BOZDER FWD & AFT FACES

WT = 1.5 (410)(.0185 + .0115) 18.6

S.W. AND FLOOR ATT ANGLES
(ASSUME $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{8}$ FWD & AFT
ATT. ANGLES

WT = 3(410)(.125)(2) = 30.8

ACCESS DOOR (39 X 48)

W_{AL} (DCB ACCESS DOORS = 3.6 #/FT²)

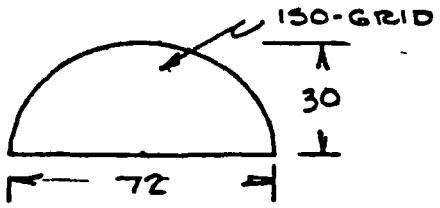
WT DEUALTY = 39(48)(3.6)/144 = 46.8

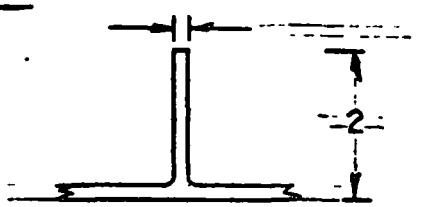
ATT. AND MISC (5%)

WT = 380.5(.05) = 19.5

400±

FWD PRESS BULKHEAD





150-GRID SECTION

$S \approx \frac{3.14}{2}(33)^2 = 1709 \text{ IN}^2$
$= 11.86 \text{ FT}^2$

$\alpha = \frac{bd}{tn}$; $b = t$

$\alpha = \frac{2}{13.5(66)} = .17$

$\bar{t} = t(1+3\alpha) = .264(1.51) = .399$

FWD PRESS BULK (CONT.)

WEIGHT

ISO GRID PANEL

WT = 1709 (.399)(0.1) = 68.2

SIDEWALL/FLR ATT. ANGLE
(ASSUME $1\frac{1}{2} \times 1\frac{1}{2} \times .25$ ANGLE)

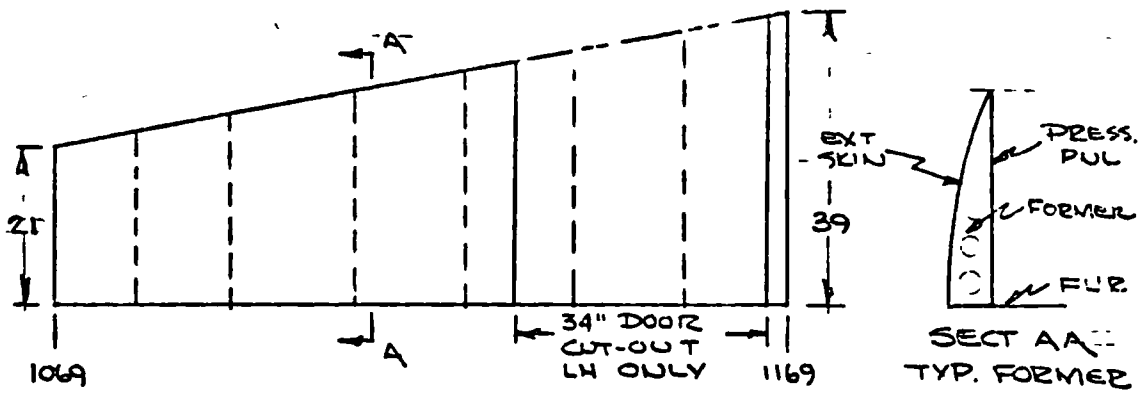
WT = 170(3)(.025) = 12.8

ATTACH & MISC

WT = 81 (05) = 4.0

85#

LONGITUDINAL PRESS PANELS



REQ GAGE PRESS. PUL

$$\sigma_{MAX} = \frac{.075 w b^2}{t^2(1+1.61\alpha^3)} \quad \text{REF "ZOAEK"}$$

$w = 2.0(109) = 21.8$ PSIA (ULT)

$\sigma_{ALLOW} = 69000\#/IN^2$

LET $b = 4"$ $\quad \alpha = b/a = 4/15 = .267$

$$t^2 = \frac{0.75(21.8)(16)}{69000(1.031)} = \frac{261.6}{71139} = .00368$$

$t = .0606$ USE .063

LONG. STRINGERS

ASSUME $1199981 BULB TEES 4" O.C.

H = 1.25" C = 1.25 - .5 = .75" $\Delta\bar{t} = \frac{.191}{4} = .048$

A = .191 IN² I = .0292 IN⁴

$M_{MAX} \approx \frac{1}{8} wl = \frac{4(15)(218\ PSI)(15)}{8} = 1308$ IN-LBS

$\sigma = \frac{Mc}{I} = \frac{1308(.75)}{.0392} \approx 47000\#/IN$ { SEEMS REASONABLE FOR MAX FIBER BENDING STRESS

WEIGHTS

R.H. PNL (.063 AL)	
WT = 100(30)(.0063) =	18.9
LH PNL (.063 AL)	
WT = 66(26)(.0063) =	10.8
RH STRINGERS ($1199981)	
WT = 3000(.0048) =	14.4
LH STRINGERS ($1199981)	
WT = 1716 (.0048) =	8.2
FORMERS (.050 AL) -	
WT = 150 IN² X .005 X 12 REQ =	9.0
ATT ANGLES (STA 1069 & 1169)	
WT = 3(30)(.0063)(4) =	2.3
FLOOR & SW ATT ANGLE	
WT = 4(102+100)(.063)(2)	10.2
MISC & ATT.	
WT = 73.8(.05) ≈	4.2
	780#

WINDSHIELD INSTALLATION

THE WEIGHT OF THE WINDSHIELD INSTALLATION IS BASED ON THE UNIT WEIGHT OF THE DC-10 COCKPIT ENCLOSURE.

DC-10 COCKPIT ENCLOSURE = 980 LB

AREA OF DC-10 WINDSHIELD:

FRONT AREA $= 2\left[30.6(24.6) + 10.2\left(\frac{30.8}{2}\right)\right]$

$= 2(753 + 157) = 1820\ IN^2$

SIDE AREA $= 2\left[34.8(31) + 32.6(7.6) + 6.3(22.2) + 19.8(18.5)\right]$

$= 2(1,080 + 248 + 140 + 366) = 3,668\ IN^2$

TOTAL AREA $= 5,488\ IN^2 = 38.1\ FT^2$

DC-10 UNIT WT $= 980 / 38.1 = 25.7\ LB/FT^2$

SHUTTLE BOOSTER WINDSHIELD AREA.

FRONT AREA $= 2[23(35.5)] = 1632\ IN^2$

SIDE AREA $= 2[17(26)] = 884\ IN^2$

TOTAL AREA $= 2516\ IN^2 = 17.5\ FT^2$

WINDSHIELD INSTALLATION $= 17.5(25.7) =$ **450 LB**

CREW DOOR (30 x 48 CLEAR)

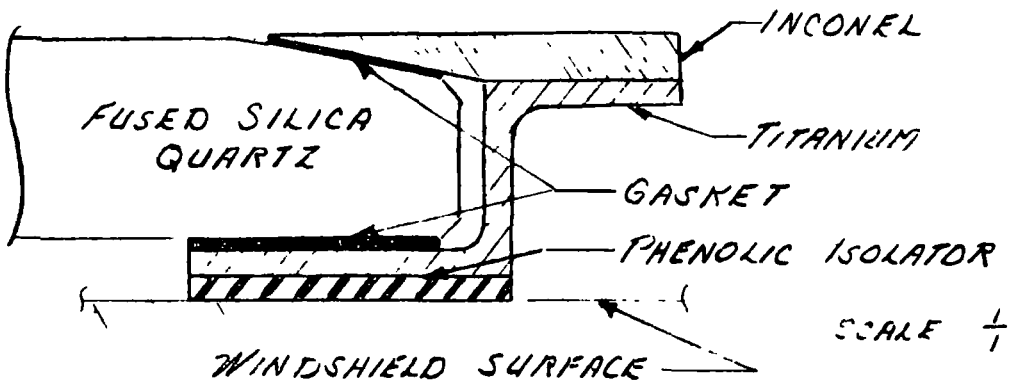
$S = \frac{34(51.4)}{144} = 12.14\ FT^2$

W (PENALTY DOOR SEAL DOORS) $= \frac{461}{30.7} = 14.53^{\#}/FT^2$

EST. WT PENALTY D'RE JMB $= 12.14(14.53) =$ **176#**

WINDSHIELD THERMAL PROTECTION

THE WINDSHIELD THERMAL PROTECTION CONSISTS OF A 1" THICK SHEET OF FUSED SILICA QUARTZ OVER THE SURFACE OF THE WINDSHIELD



TYPICAL FUSED SILICA QUARTZ-FRAME CROSS SECTION

INCONEL
AREA = 1.63(.25) = 0.407 IN²
WT = ALρ = 0.407(1)(.310) = 0.126 LB/IN

TITANIUM
AREA = (17+.7+.9)(.125) +2(.01341) = 0.439 IN²
WT = ALρ = 0.439(1)(.161) = 0.076 LB/IN

PHENOLIC ISOLATOR
AREA = 1.7(.125) = 0.213 IN²
WT = ALρ = 0.213(1)(.049) = 0.011 LB/IN

GASKET
AREA = 1.3(.075) + .9(.04) = 0.139 IN²
WT = ALρ = 0.139(1)(.05) = 0.007 LB/IN

TOTAL FRAME & INSULATOR WT = 0.220 LB/IN

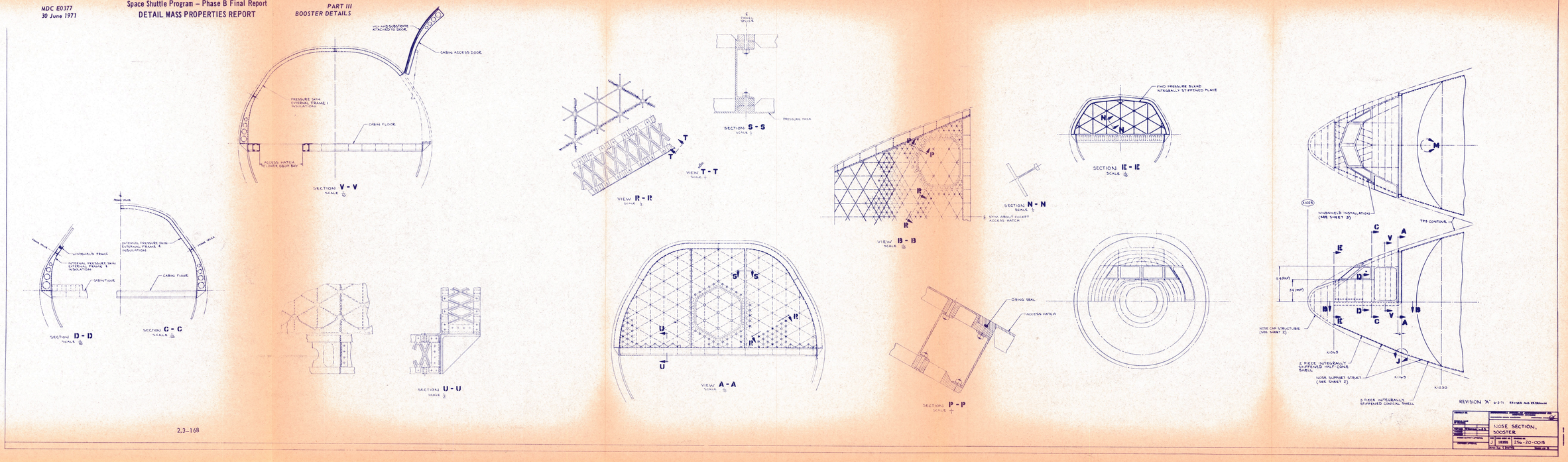
TOTAL FRAME LENGTH
$L = 2\left[2(35.5+23) + (18+36.5+23+16)\right] = 421$ IN

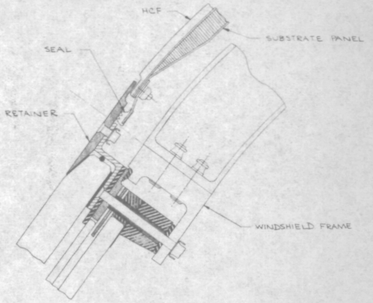
TOTAL FRAME & INSULATOR WT = 421(.220) = 93 LB

FUSED SILICA QUARTZ
AREA = 2[23(35.5) + 17(26)] = 2,516 IN²
WT = ALρ = 2,516(1)(.0794) = 200 LB

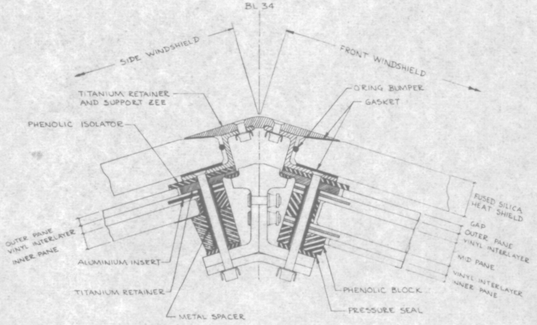
MISCELLANEOUS & ATTACH PARTS 9 LB

TOTAL WINDSHIELD TPS INSTALLATION **302 LB**

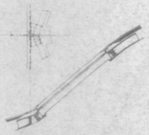

SECTION V - V
SECTION S - S
VIEW R - R
VIEW T - T
SECTION E - E
SECTION N - N
VIEW B - B
SECTION D - D
SECTION C - C
SECTION U - U
VIEW A - A
SECTION P - P
NOSE SECTION, BOOSTER
J 18356 256-20-0015
REVISION "A" 6-2-71 REVISED AND REDRAWN



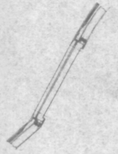
VIEW IV
SCALE 1/1



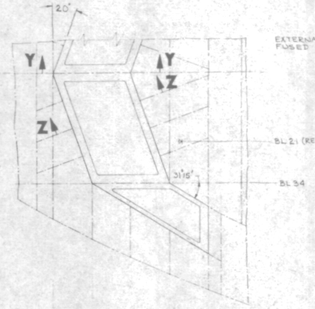
VIEW X
ROTATED 75° CLOCKWISE
SCALE 1/1

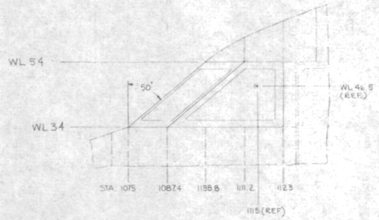


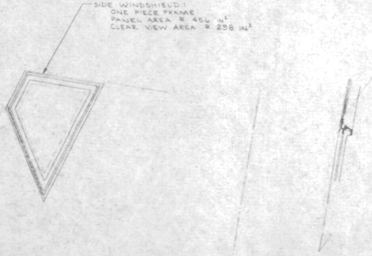
SECTION Y - Y
SCALE 1/10

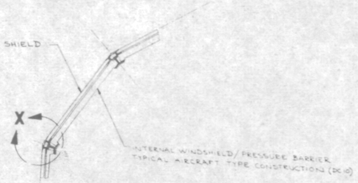


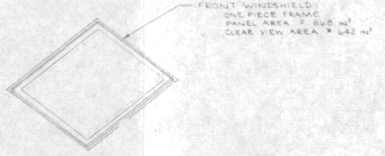
SECTION Z - Z
SCALE 1/10











REVISION A

CONTRACT NO	MCDONNELL DOUGLAS ASTRONAUTICS CO. WESTERN DIVISION
ORIGINAL DATE OF DRAWING	
PREP AREA	NOSE SECTION, BOOSTER
CHECKED	
ENGINEER	
DESIGN ACTIVITY APPROVAL	SIZE J · CODE IDENT NO 18355 · DRAWING NO 256-20-0015
CUSTOMER APPROVAL	SCALE NONE · SHEET 3 OF 3

WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
⑧⑨ DOORS - LANDING GEAR		[1302]
⑧ NOSE GEAR DOOR	170	(355)
DOOR		273
JAMB		72
MISCELLANEOUS & ATTACH PARTS		10
⑨ MAIN GEAR DOORS	171	(947)
DOORS & JAMB		784
OPERATING MECHANISM		92
ACTUATION		46
LOCK MECHANISM		25

NOSE GEAR DOOR

DOOR AREA = 101 FT²

DOOR WEIGHT 2.7 LB/FT² BASED ON ZC-8 NOSE DOOR

DOOR WEIGHT = 2.7(101) = 273

JAMB:

PERIPHERY = 548 IN

JAMB IS EQUIVALENT TO A TOTAL CIRCUMFERENTIAL JOINT = (.066+.066) = 0.132 LB/IN *

JAMB WT = 548(0.132) = 72

MISC. & ATTACH PARTS 10

TOTAL DOOR & JAMB 355 LB

* SEE DETAIL CALCULATIONS IN INTERTANK CALCULATIONS PAGE 2.3.

MAIN LANDING GEAR DOOR & JAMB

DOOR AREA

$A = 50(158) = 7,900\ IN^2/SIDE = 54.8\ FT^2/SIDE$

$WT = 7.15\ LB/FT^2$ (BASED ON DC-10 MAIN GEAR DOORS)

$TOTAL\ WT = 2(54.8)(7.15) + 163 =$ **947 LB**

BASIS ESTIMATE BASED ON THE FOLLOWING

DC-10 MAIN GEAR DOORS

AREA = 61.5 FT^2/DOOR

ITEM	WEIGHT IN FUSELAGE	WEIGHT IN WING	TOTAL WEIGHT
DOOR & JAMB	608	272	880
OPERATING MECHANISM	84	8	92
ACTUATION	46	—	46
LOCK MECHANISM	25	—	25
HYDRAULIC FLUID	8	—	8*

$DOOR\ \&\ JAMB = \frac{880}{123} = 7.15\ LB/FT^2$

$MECHANISMS\ \&\ FLUID = 92 + 46 + 25 = 163\ LB$

* WEIGHT INCLUDED IN RESIDUALS

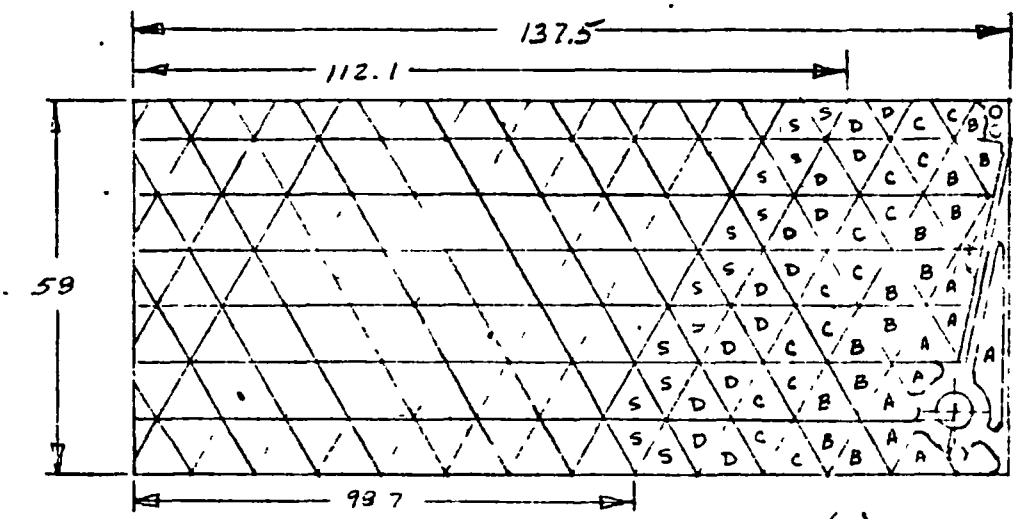
WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
(10)(11)(12)(13) GEAR / WING PROVISIONS		[4352]
(10) NOSE GEAR WELL		(875)
SIDE PANELS	174	537
COVER	179 & 180	192
TRUSS	181	3
WEB IN FRAMES	182	61
MISCELLANEOUS & ATTACH PARTS		56
CONTINGENCY - 3 %		26
(11) MAIN GEAR PICKUP		(5084)
TRUSS UPPER HALF-STA 3635	184 & 185	761
TRUSS LOWER HALF-STA 3635	186 & 187	548
CENTER TRUSS - STA 3660	188 & 189	438
LOAD PICK-UP FITTING	196	80
TRUSS UPPER HALF-STA 3685	190 & 191	798
TRUSS LOWER HALF-STA 3685	192 & 193	636
INTERCOSTALS	194	428
TRUSS TORQUE BOX PANELS	195	896
PANEL SUPPORT ANGLES	196	37
MISCELLANEOUS & ATTACH PARTS		462
(11) MAIN GEAR ENCLOSURE		(647)
ENCLOSURE PANELS	197 TO 203	310
PANEL SUPPORT ANGLES	204	157
PANEL STIFFENERS	204	107
DOOR PENALTY	205	14
MISCELLANEOUS & ATTACH PARTS		59
(11) REDESIGN OF MAIN GEAR PICK-UP	144 TO 158	(-3377)

WEIGHT SUBSTANTIATION

ITEM	SEE PAGE 2.3-	TOTAL WEIGHT
⑩⑪⑫⑬ GEAR/WING PROVISIONS-CONTINUED		
⑫ CANARD ATTACH		(578)
TRUSS-STA 1953	207	115
TRUSS-STA 2093	217	289
TRUSS BRACES	208	103
SHEAR PANEL	200	54
MISCELLANEOUS & ATTACH PARTS		17
⑬ WING LEADING EDGE ATTACH		(545)
"4" FINGER SECTIONS	[illegible]	140
"2" FINGER SECTIONS	217 TO 223	74
STRUTS	[illegible]	72
FITTING-INNER HALF	225 TO 227	30
FITTING-OUTER HALF	[illegible]	72
ATTACH PARTS	[illegible]	40
SPECIAL FINGER ATTACH PLUGS	229 TO 235	99
MISCELLANEOUS		18

SIDE PANEL - 2 REQUIRED



ALL UNMARKED POCKETS ARE STANDARD (S)

SUMMARY

	# NO	AREA (IN²)	t̄		WT.
STANDARD ("S") POCKETS	129	5573	.111		65.3
"D" "	13.3	530	.302		17.5
"C" "	13 3	590	.513	PAGE 2.3-176	29.8
"B" "	12.4	534	.784		41.9
"A" "	8	346	.979		33.8
					188.3

16

INTEGRAL FITTING — PAGE 2.3-177 — 54.8
NON ISOGRID AREA — PAGE 2.3-178 — 4.5
PERIPHERIAL BEEF-UP — PAGE 2.3-178 — 20.9

TOTAL/PANEL (2 REQ) 268.5

TOTAL SIDE PANEL WT = 2(268.5) = **537 LB**

NO ALLOWANCE HERE FOR FASTENERS

$\bar{t}$ DETERMINATION

POCKET DESIG'N	t_s	b	d	a	R	r	$\bar{t}$
"S"	.060	.080	1.44	10	.75	.125	.111
"D"	.180	.200	1.62	10	.75	.125	.302
"C"	.280	.320	2.02	10	.75	.125	.513
"B"	.400	.460	2.40	10	.75	.125	.784
"A"	.500	.560	2.50	10	.75	.125	.979

t_s IS WEB THICKNESS

b IS TOTAL RIB WIDTH*

d IS AVERAGE HEIGHT OF RIB ABOVE WEB

a IS CENTER DISTANCE (NODE TO NODE)

R IS NODE RADIUS & POCKET FILLET RADIUS

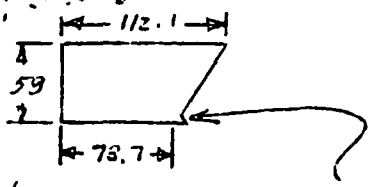
r IS RADIUS OF FILLET AT RIB-WEB JUNCTURE

THE TABULATED VALUES FOR THE ABOVE PARAMETERS WERE USED IN A ISOGRID $\bar{t}$ DETERMINATION PROGRAM CREATED FOR USE WITH THE OLIVETTI PROGRAMA 101.

* LMMSC 256-20-0017 DESIGNATES b AS 1/2 OF THE RIB WIDTH

BREAK DOWN OF PANEL AREA:

"STANDARD POCKETS"

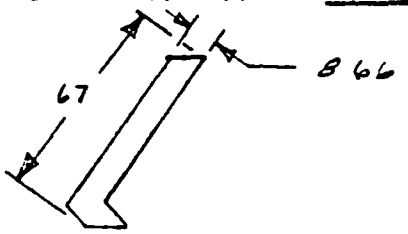


AREA = 58 × (112.1 + 78.7)/2 + AREA OF ONE POCKET
= 55 × 95.4 + 43.3 = 5530 + 43 = 5573 IN²

THE $\bar{t}$ FOR THE STANDARD POCKET IS .111

∴ WT = 5573 × .111 × .1 = 65.3 lb

"D" POCKETS



AREA = 67 × 8.66 = 580 IN²

$\bar{t}$ for "D" POCKETS IS .302

WT = 580 × .302 × .1 = 17.5 lb

"C" POCKETS

SAME AREA A "D" ABOVE = 580 IN²

$\bar{t}$ for "C" POCKETS IS .513

WT. = 580 × .513 × .1 = 29.8 lb.

"B" POCKETS

COUNTING POCKETS ≈ 12.4

AREA = 43.3 × 12.3 = 534 IN²

$\bar{t}$ = .784

WT = .784 × 534 × .1 = 41.9 lb

"A" POCKETS

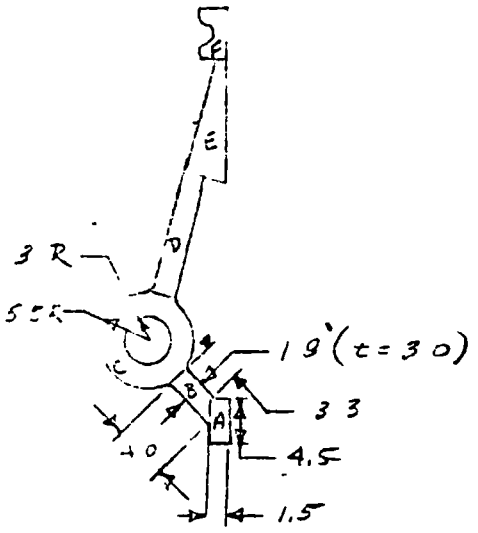
COUNTING POCKETS ≈ 9

AREA = 9 × 43.3 = 346 IN²

$\bar{t}$ = .979

WT = 346 × .979 × .1 = 33.9 lb.

INTEGRAL FITTING



SUMMARY

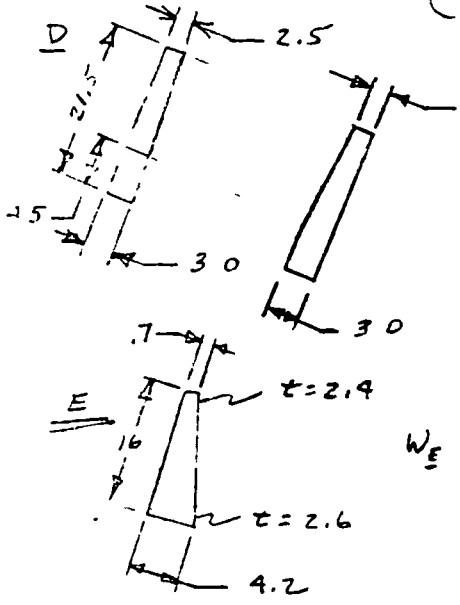
ITEM	WT.
A	2.0
B	2.0
C	20.2
D	17.3
E	10.1
F	3.2
TOTAL	54.8 lb.

A WT = $1.5 \times 4.5 \times 3.0 \times .1 =$ 2.0 lb

B WT = $19 \times (4.0 + 3.3)/2 \times 3.0 \times .1 =$ 2.0 lb

C WT = $.1 \times 3.0 \left(5.5^2 - 3^2\right) \pi =$ 20.2 lb

D



WT = .1 [(3 x 3 x 4.5) − 17(2.6 x 1.5 + 3.0 x 3.0)/2]

= .1 [40.5 + 8.5(6.5 + 9)]

= .1 [40.5 + 132] = 172.5 x .1

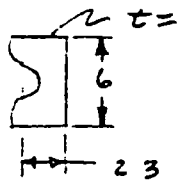
WT = 17.3 lb

E

W_E = .1 [16] [(.7 x 2.4 + 2.6 x 4.2)/2]

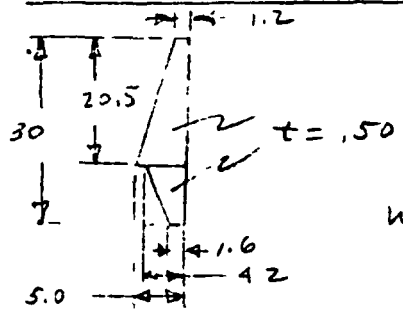
= 1.6 (1.63 + 10.9) = 10.1

F



WT = .1 x 2.3 x 6 x 2.3 = 3.2

NON ISOGRID AREA ADJACENT TO INTEGRAL FITTING

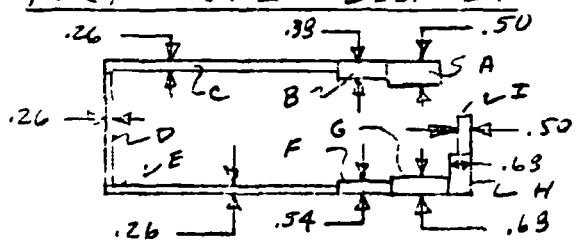


$WT = .1[.50][20.5(1.2+5.0)/2 + 9.5(4.2+1.6)/2]$

$= .025[127 + 55] = .025[182]$

$= 4.5$ lb.

PERIPHERIAL BEEF-UP



A $WT = .1 \times 2.25[2.5 \times (.50 - .23) + 11.5(.50 - .16)] = .225[.675 + 3.9]$
$= .225 \times 4.6 = 1.0$ lb

B $WT = .1 \times 2.25[16 \times (.38 - .10)] = .225[4.5] = 1.0$ lb

C $WT = .1 \times 1.5[102(.26 - .04)] = .15[102 \times .22] = 3.4$ lb

D $WT = .1 \times 1.5[52(.26 - .04)] = .15[52 \times .22] = 1.9$ lb

E $WT = .1 \times 1.5[99(.26 - .04)] = .15[99 \times .22] = 2.9$ lb.

F $WT = .1 \times 2.00[20(.54 - .1)] = .2[20 \times .44] = 2.6$ lb

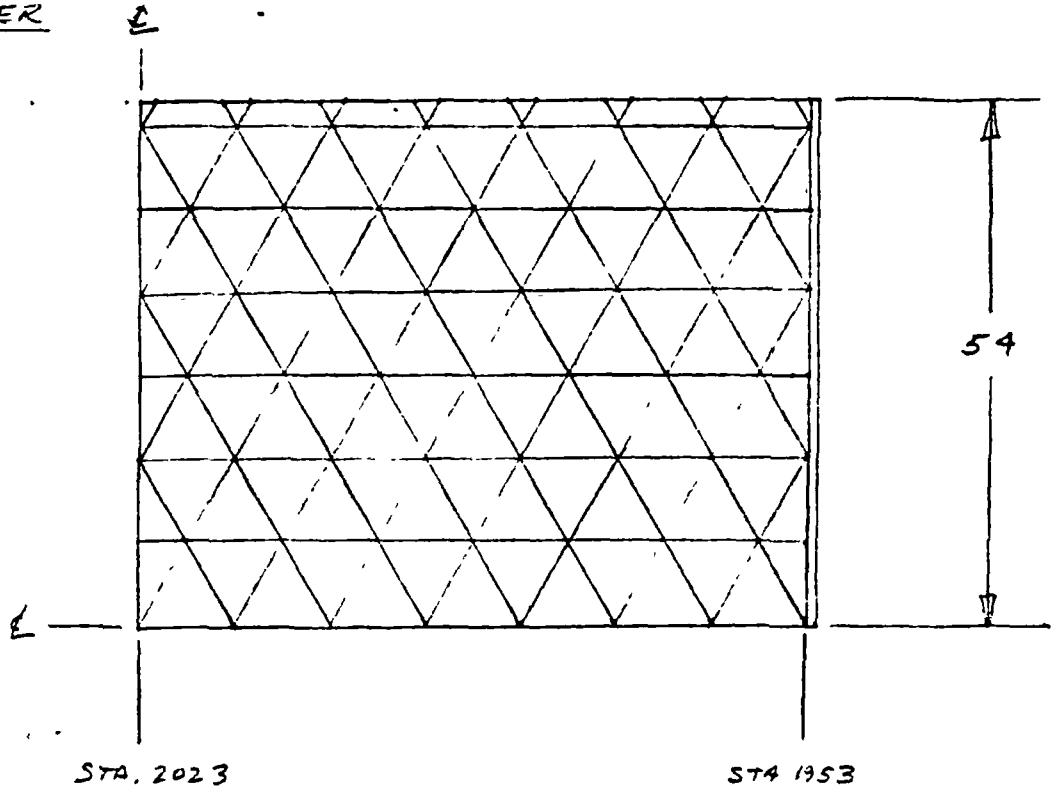
G $WT = .1 \times 3.00[13(.60 - .28)] = .3[13 \times .4] = 2.2$ lb

H $WT = .1 \times 3.00[14(.63 - 0)] = .3[14 \times .63] = 2.9$ lb.

I $WT = .1 \times 3.00[20(.50 - 0)] = 3.0$ lb.

TOTAL EDGE BEEF-UP = 20.9 lb

COVER



$\bar{t}$ DETERMINATION COVER 10" POCKETS

$t_s = .07$ $b = .08$ $d = 1.18$ $R = .75$ $r = .125$

THIS YIELDS A $\bar{t}$ OF .106

WT OF BASIC PANEL (NOT INCLUDING BEEFUPS, CUTOUTS, ETC.)

$WT = \rho \bar{t} A$

$= .1 \times .106 \times 54 \times 71 = 40.7$ lb.

PANEL EDGE CONSIDERATIONS

PANEL AT STA 2023 WHERE TRUSS ATTACHES

ASSUME A 1.5" CAP .1" THICK

$WT = \left(1.5/2 \times .1 \times 54\right) \times .1 = .4$ lb

PANEL AT VEHICLE CENTERLINE

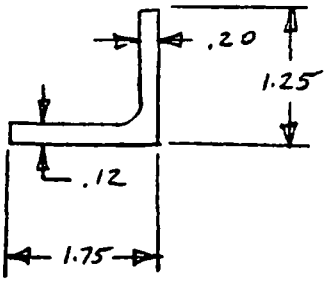
X-SECTION AREA $= .12 \times 1.75 + .20 \times 1.13$

$= .21 + .226$

$= .436$ IN^2

$WT = L A \rho = 70 \times .436 \times .1$

$= 3.1$ lb



PANEL EDGES WHERE IT JOINS FRAMES & SIDE PANEL

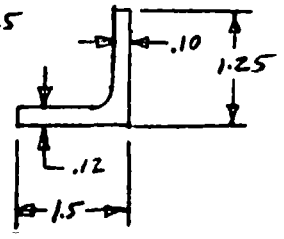
X-SECTION AREA $= 12 \times 1.5 + .10 \times 1.25$

$= .18 + .125$

$= .305$ IN^2

$WT = L A \rho = (54+70)(.305)(.1)$

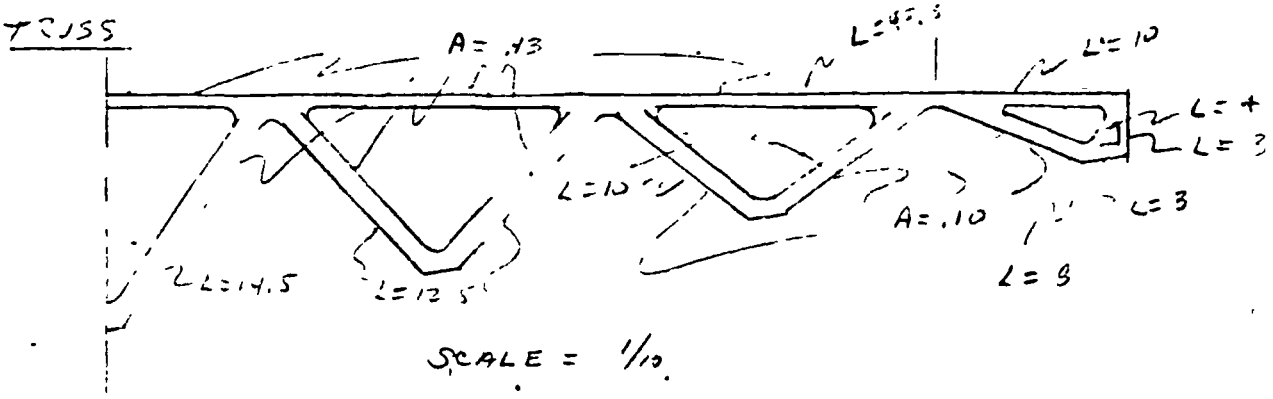
$= 3.8$ lb.



SUMMARY

BASIC PANEL	40.7
BEEF-UP AT TRUSS	0.4
BEEF-UP AT VEHICLE ℄	3.1
BEEF-UP AT EDGE JOINING FRMS & SIDE PANEL	3.8
	48.0 4 REQ

TOTAL WT = 4(48) = **192 LB**

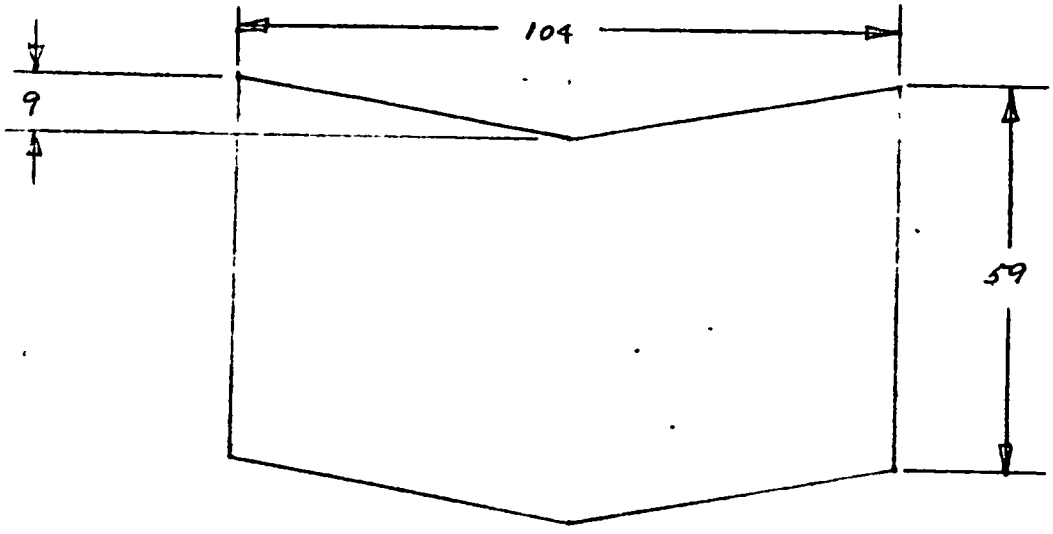


$$WT = L A_1 = (43.5 + 14.5 + 12.5 + 12.5 + 10.0)(.13)(.10) +$$
$$- (10 + 4 + 3 + 3 + 8 + 10)(.10)(.1)$$
$$= (93)(.013) + (32 \times .01)$$
$$= 1.2 + .4 = 1.6 \text{ lb.} \quad 2 \text{ REQ.}$$

$$WT = \boxed{3.2 \text{ lb.}}$$

FRAME WEBBING – STATIONS 1953 & 2093

THE CURRENT PLANS FOR THIS IS TO INTEGRALLY MACHINE THE WEBS INTO THE AREA BETWEEN THE VERTICAL FRAME DIAGONALS IN THE AREA OF THE NOSE WELL.



THE WEB WILL BE .050 THICK

$A = 104 \times 59 = 6140 \text{ IN}^2$

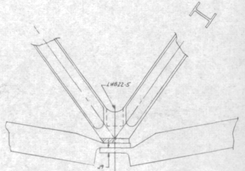
$WT = A \times \rho = 6140 \times .050 \times .1 = 30.7 \text{ lb.}$ (2 REQ.)

61.4 lb TOTAL

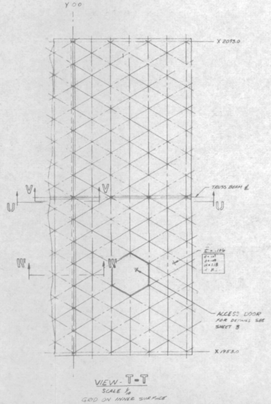
SECTION W-W
SCALE FULL
TOP SKIN PANEL ℄ JOINT

VIEW U-U
SCALE ½

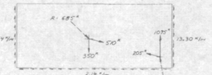
SECTION X-X
SCALE FULL
TOP PANEL TO BHD & FASTIE JOINT



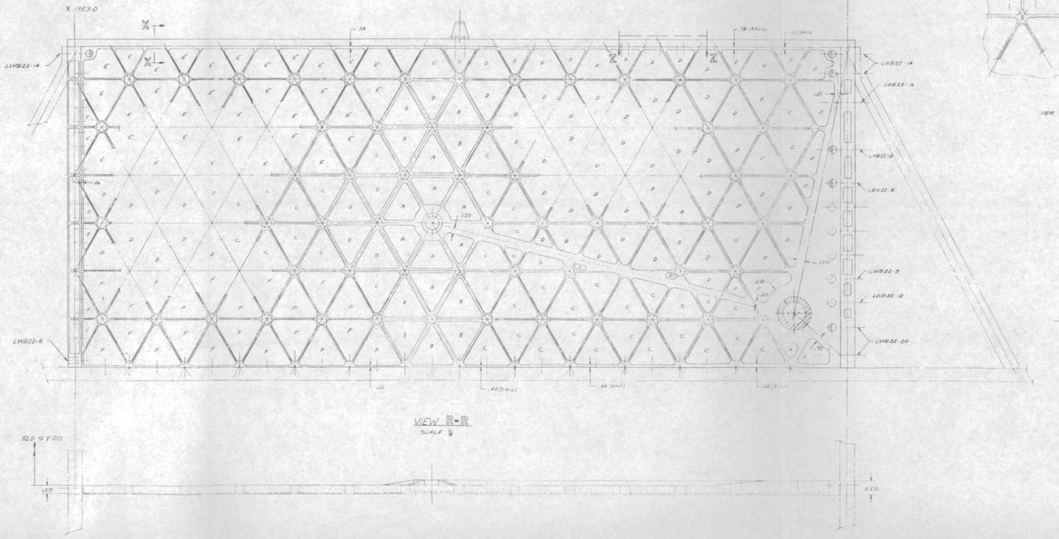
SECTION V-V
SCALE - FULL
SECTION AT BOOM CHAY



VIEW T-T
SCALE ½
GOO ON INNER SURFACE

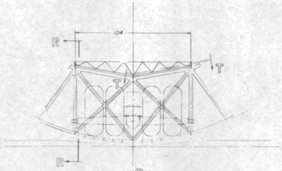


FREE BODY DIAGRAM OF WHEEL, PAEL SIDE WALL SHOWING LOADS APPLIED BY LANDING GEAR AND SEAL SUPPORT REACTIONS



VIEW R-R
SCALE ½

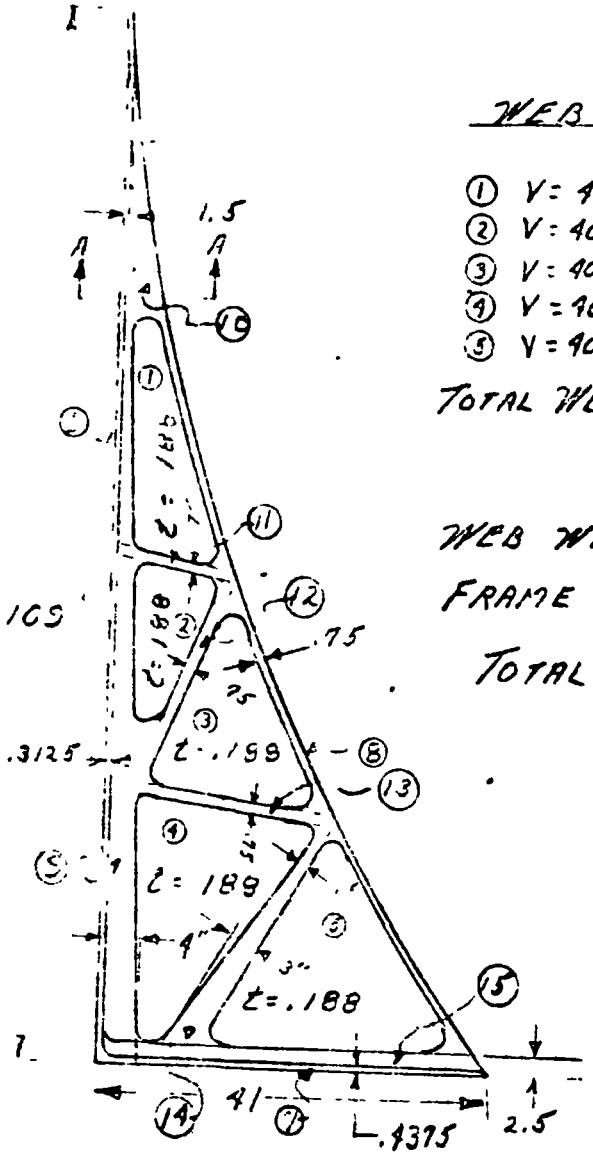
VIEW R-R
SCALE - FULL
TOP TOP PANEL EDGE ATTACH
VIEW ROTATED 90° INTO PLANE OF PAPER



VIEW C
SCALE ½

NOSE GEAR SUPT BHD & WHEEL WELL

STA 3635 - UPPER HALF OF END TRUSS



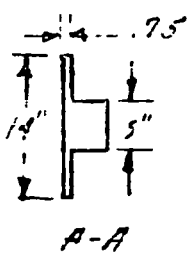
WEB VOLUME

①	V = 400(.345)(.188)	=	26
②	V = 400(.235)(.188)	=	25
③	V = 400(.5)(.188)	=	38
④	V = 400(.67)(.188)	=	50
⑤	V = 400(.715)(.188)	=	54
TOTAL WEB VOLUME		=	193 IN^3/SIDE

WEB WT = 2VP • 2[193(.101)] = 39 LB

FRAME WT = 722 LB

TOTAL FOR UPPER HALF **761 LB**



A-A

STA 1035 - UPPER HALF OF FWD TRUSS

VOLUMES

⑥	$V = 14(109)(.3125)$	=	477
⑦	$V = 14(.69)(.4375)$	=	249
⑧	$V = 5(103)(.75)$	=	386
⑨	$V = 5(91)(\frac{3.49+1.49}{2})$	=	1,110
⑩	$V = 5(15)(17)$	=	128
⑪	$V = 5(.75)(11.5)$	=	43
⑫	$V = 5(75)(.24)$	=	90
⑬	$V = 5(.75)(20.5)$	=	77
⑭	$V = 5(275)(\frac{3^2+1.5^2}{2})$	=	309
⑮	$V = 5(35)(2.5-.4375)$	=	361
			(3,230) IN^3

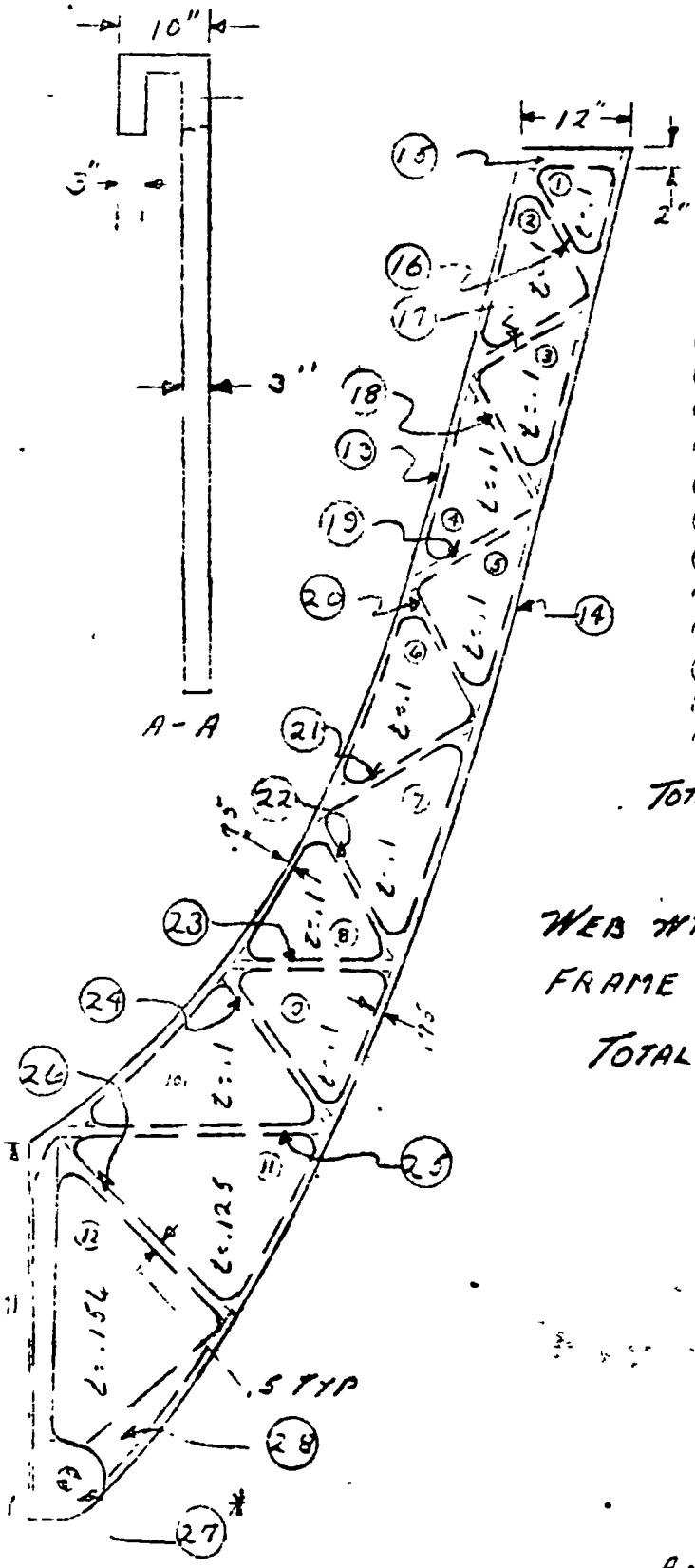
FILLETS

$$V = 5[1+1+7.5+2+2+1+1+3] + 78(3) + 200(.05365) = 338\ IN^3$$

TOTAL VOLUME 3,568 IN^3/SIDE

$WT = 2[3,568(.101)] =$ 722 LB

STA 3635 - LOWER HALF OF END TRUSS



WEB VOLUME

①	V = 400(.14)(.1) =	6
②	V = 400(.275)(.1) =	11
③	V = 400(.25)(.1) =	10
④	V = 400(.28)(.1) =	11
⑤	V = 400(.29)(.11) =	12
⑥	V = 400(.283)(.1) =	11
⑦	V = 400(.38)(.1) =	15
⑧	V = 400(.29)(.1) =	12
⑨	V = 400(.36)(.1) =	14
⑩	V = 400(.55)(.1) =	22
⑪	V = 400(.7)(.125) =	35
⑫	V = 400(.8)(.156) =	50
	TOTAL WEB VOLUME =	209 IN³/SIDE

WEB WT = 2VP = 2[209(.101)] = 42 LB

FRAME WT = 506 LB

TOTAL FOR LOWER HALF 548 LB

* INCLUDES BOTH SIDES

STA 2625 - LOWER HALF OF FWD TO

VOLUMES

(13)	V = 3 (125)(.75)	= 281
(14)	V = 3 (160)(.75)	= 360
(15)	V = 3 (14.5)(2)	= 63
(16)	V = 3 (14.5)(.5)	= 22
(17)	V = 3 (14.5)(.5)	= 22
(18)	V = 3 (15)(.5)	= 23
(19)	V = 3 (15)(.5)	= 23
(20)	V = 3 (15)(.5)	= 23
(21)	V = 3 (19)(.5)	= 29
(22)	V = 3 (17)(.5)	= 26
(23)	V = 3 (17.5)(.5)	= 26
(24)	V = 3 (19.5)(.5)	= 29
(25)	V = 3 (29)(.5)	= 44
(26)	V = 3 (26.5)(.5) .894	= 40
(27)	V = 2[32(2.75) + 4(9) + $\frac{\pi}{2}$(4)^2]3 + 4(2)(40.25)	= 1,216
(28)	V = 3 (2)(20)	= 120
		(2,347) IN^3

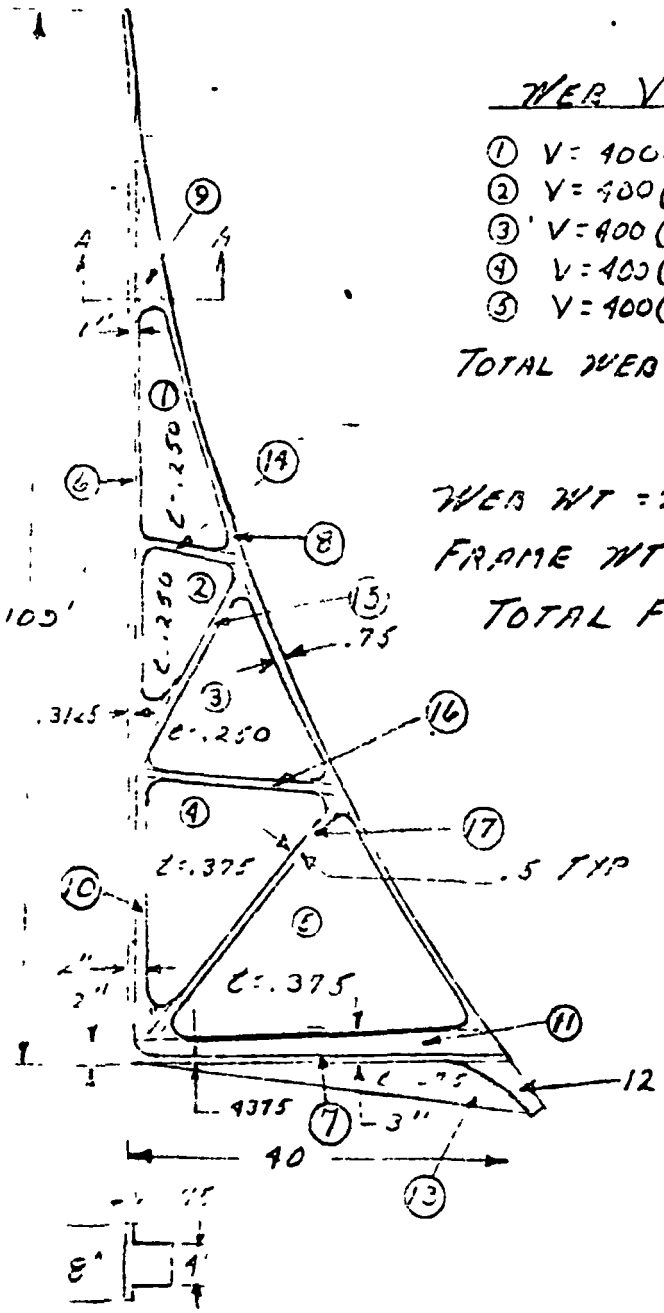
FILLETS

V = .5[.6 + 3 + 2 + 1.5 + 4.5 + 9.5 + 4.5 + 2 + 4
+ 2 + 2 + 2 + 2 + 2 + 1 + 3 + 1 + 1 + 2 + 2
+ 3 + 2 + 1] = 158

TOTAL VOLUME = 2,505 IN^3/SIDE

WT = 2 VP = 2 [2,506(.101)] = 506.60

STA 3660 - CENTER TRUSS



WEB VOLUME

①	V = 400(.35)(.250)	=	35
②	V = 400(.25)(.250)	=	25
③	V = 400(.5)(.250)	=	50
④	V = 400(.68)(.375)	=	102
⑤	V = 400(.98)(.375)	=	147
	TOTAL WEB VOLUME		359 IN³/SIDE

WEB WT = 2VP = 2[359(.101)] = 73 LB

FRAME WT = 365 LB

TOTAL FOR CENTER TRUSS **438 LB**

STA 3660 - CENTER TRUSS

VOLUMES

(6)	$V = 8(109)(.3125)$	=	273
(7)	$V = 8(39.69)(.4375)$	=	139
(8)	$V = 4(104)(.75)$	=	312
(9)	$V = 4(16.5)(14)$	=	92
(10)	$V = 4(93.5)(.844)$	=	316
(11)	$V = 4(35.5)\left(\frac{2.56+1.56}{2}\right)$	=	292
(12)	$V = 4[175(6.5) + 2(4)]$	=	78
(13)	$V = [2(\overset{64}{32}) + 2(\overset{16}{8})].375$	=	30
(14)	$V = 4(10.5)(.5)$	=	21
(15)	$V = 4(21)(.5)$	=	42
(16)	$V = 4(20)(.5)$	=	40
(17)	$V = 4(32)(.5)$	=	64
			(1,699 IN³

FILLETS.

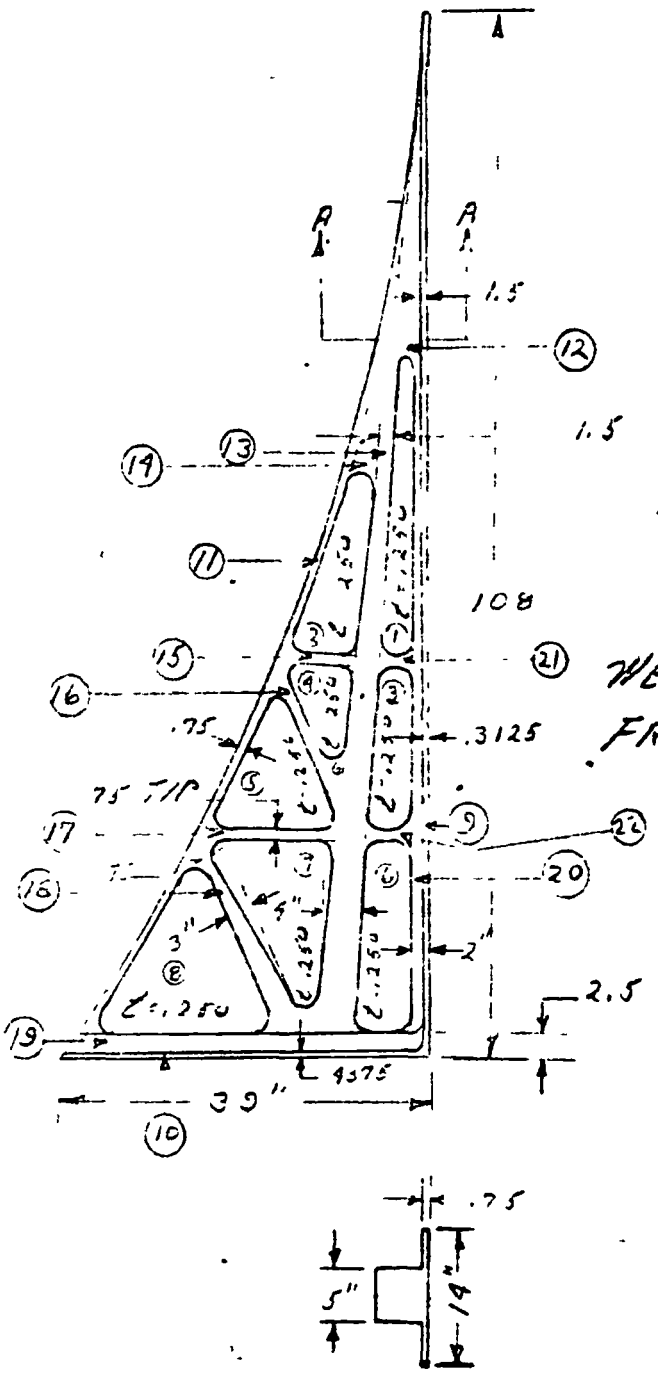
$V = 4[.25 + 1 + .5 + .5 + 7.5 + .5 + 1 + .5 + 1 + .5 + 5.2 + 26 + 1] + 2(130)(.05365)$

$= 88.2 + 13.9$ = 103 IN³

TOTAL VOLUME = = 1,802 IN³/SIDE

FRAME WT = 2[1,802(.101) = 365 LB

STA 3685 - UPPER HALF OF AFT TRUSS



WEB VOLUME

①	V = 400 (21)(250)	= 21
②	V = 400 (.22)(.250)	= 22
③	V = 400 (.16)(.250)	= 16
④	V = 400 (.11)(.250)	= 11
⑤	V = 400 (.265)(.250)	= 27
⑥	V = 400 (.25)(.250)	= 25
⑦	V = 400 (.355)(.250)	= 36
⑧	V = 400 (.45)(.250)	= 45

TOTAL WEB VOLUME = 203 IN^3/SIDE

WEB WT = 2VP = 2[203(.101)] = 41 LB

FRAME WT = 757 LB

TOTAL FOR UPPER HALF 798 LB

STA 3635 - UPPER HALF AFT TRUSS

VOLUMES

(9) $V = 14(108)(.3125)$ = 473

(10) $V = 14(38.69)(.1375)$ = 237

(11) $V = 5(96)(.75)$ = 360

(12) $V = 5(.75)(25)$ = 94

(13) $V = 5(2)(92)$ = 920

(14) $V = 5(1.5)(25)$ = 188

(15) $V = 5(7)(75)$ = 26

(16) $V = 5(15)(.75)$ = 56

(17) $V = 5(14)(.75)$ = 53

(18) $V = 5(22)\left(\frac{3+75}{2}\right)$ = 206

(19) $V = 5(36)(2.062)$ = 371

(20) $V = 5(95)(75)$ = 356

(21) $V = 5(35)(2)$ = 35

(22) $V = 5(5)(1.75)$ = 44

(3,419) IN^3

FILLETS

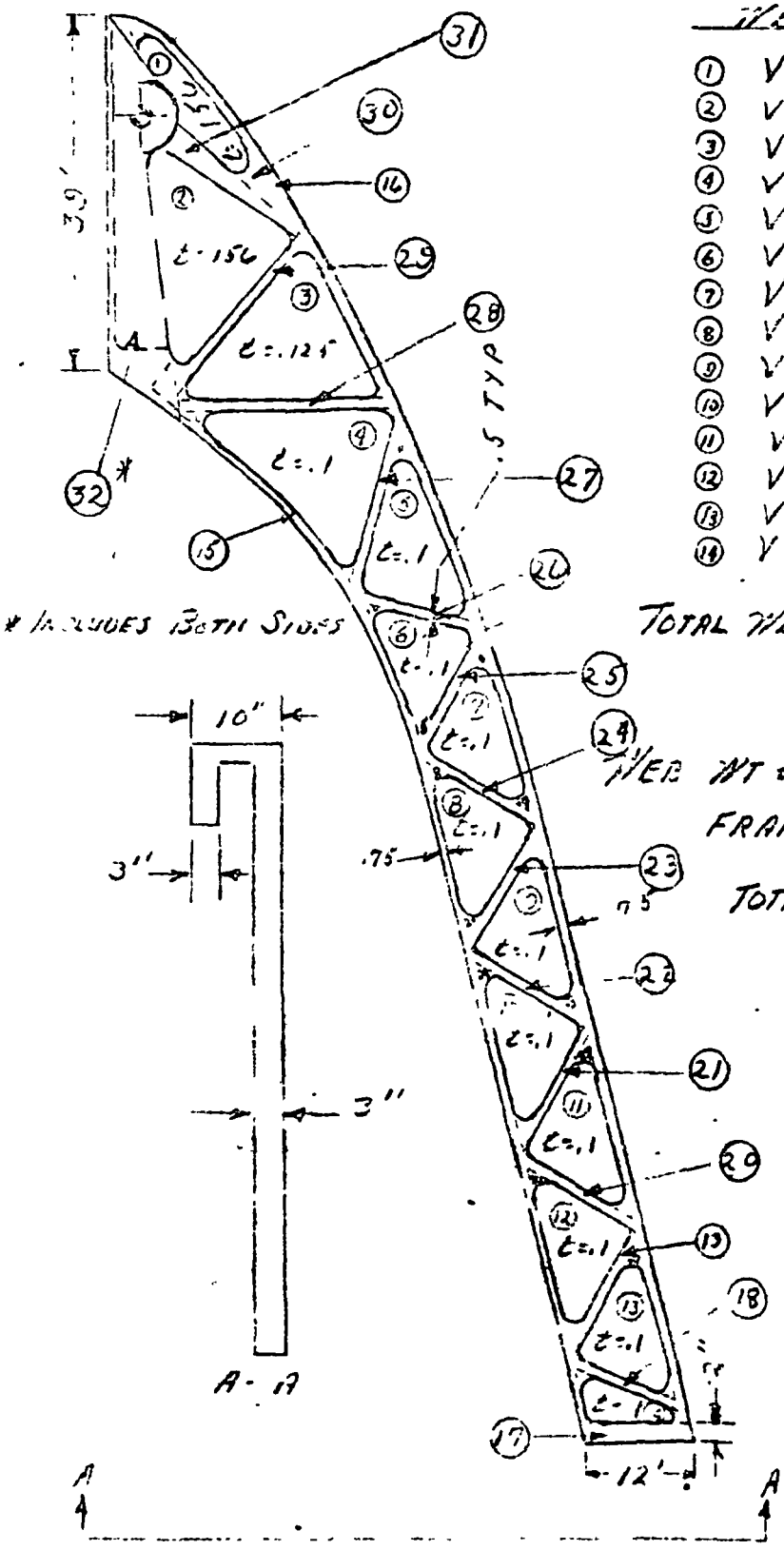
$V = 5[4 + .4 + .5 + .4 + 2 + 4 + .75 + .3$
$+ 11 + .5 + 3.1 + 1 + + 1 + 3.8 + .5 + .5]$
$+ 2(93)(.05365) + 2(36)(3)$

$= 101 + 10 + 216$ = 327 IN^3

TOTAL VOLUME = 3746 IN^3/SIDE

$WT = 2[3,746(.101)]$ = 757 LB

STA - 3695 LOWER HALF OF AFT TRUSS



WEB VOLUME

①	V = 400(.15)(.156)	=	10
②	V = 400(.5)(.156)	=	31
③	V = 400(.51)(.125)	=	26
④	V = 400(.5)(.1)	=	20
⑤	V = 400(.25)(.1)	=	12
⑥	V = 400(.2)(.1)	=	8
⑦	V = 400(.23)(.1)	=	9
⑧	V = 400(.23)(.1)	=	9
⑨	V = 400(.23)(.1)	=	9
⑩	V = 400(.24)(.1)	=	10
⑪	V = 400(.25)(.1)	=	10
⑫	V = 400(.23)(.1)	=	9
⑬	V = 400(.23)(.1)	=	9
⑭	V = 400(.076)(.1)	=	3

* INCLUDES BOTH SIDES

TOTAL WEB VOLUME 175 in³

WEB WT = 2VP = 2[175(.101)] = 36 LB

FRAME WT = 600 LB

TOTAL FOR LOWER HALF 636 LB

STA 3685 - LOWER HALF OF AFT TRUSS

VOLUMES

(15) $V = 3(121)(.75)$ = 272

(16) $V = 3(171)(.75)$ = 385

(17) $V = 3(12)(2)$ = 72

(18) $V = 3(12.5)(.5)$ = 19

(19) $V = 3(14)(.5)$ = 21

(20) $V = 3(14)(.5)$ = 21

(21) $V = 3(14)(.5)$ = 21

(22) $V = 3(14)(.5)$ = 21

(23) $V = 3(14)(.5)$ = 21

(24) $V = 3(14)(.5)$ = 21

(25) $V = 3(13)(.5)$ = 20

(26) $V = 3(13)(.5)$ = 20

(27) $V = 3(18)(.5)$ = 27

(28) $V = 3(22)(.5)$ = 33

(29) $V = 3(21.5)(.5)$ = 32

(30) $V = 3(10)(1.5)$ = 45

(31) $V = 3(19)(1.5)$ = 86

(32) $V = 2[3(7) + 5.75(23) + 8(4) + 2.5(7) + \pi(4)^2]3 + 4(2)(38)$ = 1,367 + 304 = 1,671

(2,808) IN^3

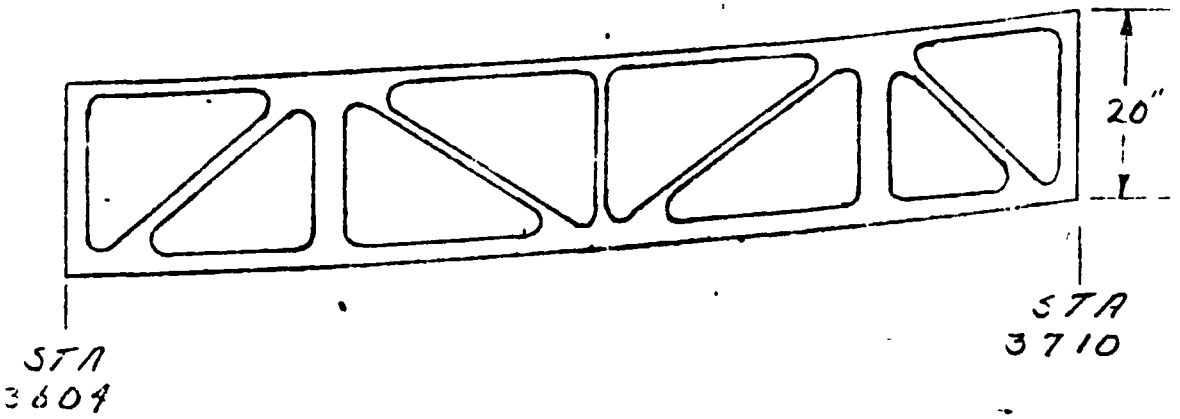
FILLETS

$V = 3[3 + .25 + .25 + 1.5 + .5 + 3 + .3 + 1.5 + 1 + .25 + 2 + 2 + .75 + 2.25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 2.25 + 2.25 + .25 + 1.25]$ = 166 IN^3

TOTAL VOLUME = 2,974 IN^3/SIDE

WT = 2 [2974 (.101)] = 600 LB

INTERCOSTAL - STA 3604 - 3710 - 2 REQ

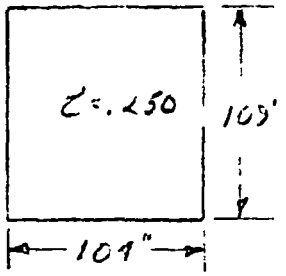


INTERCOSTAL IS DESIGNED TO MAINTAIN AN AVERAGE CROSS SECTION OF 20 IN²

$WT = 2[20(106)(.101)] =$ **428 LB**

TRUSS ASSY EMPLOYING PANELS

OUTER PANEL - 2 REQ - 1/SIDE

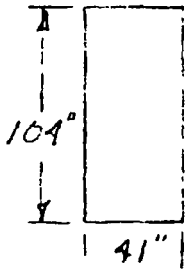


AREA = 109(104) = 11,350 IN²/SIDE

WT = 2 [11,350(.250)(.101)] = 573 LB

BOTTOM PANEL - 2 REQ - 1/SIDE

t = .375

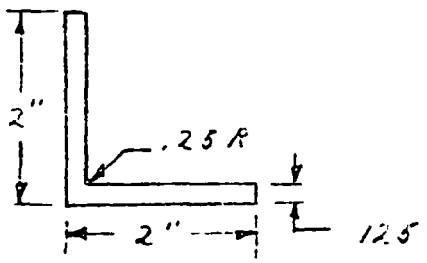


AREA = 41(104) = 4,270 IN²/SIDE

WT = 2 [4,270(.375)(.101)] = 323 LB

TOTAL PANEL WT $\boxed{896 \text{ LB}}$

TRUSS AFT ENCLOSURE PANEL SUPPORT ANGLES



CROSS SECTION AREA:

$A = (2 + 1.875).125 + .0134 = .4984\ IN^2$

LENGTH-SIDES = 2(109) =		218
LENGTH-BOTTOM = (20 + 13 + 13 + 20) + 82		148
TOTAL LENGTH REQ =		366 IN/SIDE

$WT = 2ALP = 2[.4984(366)(.101)] =$ **37 LB**

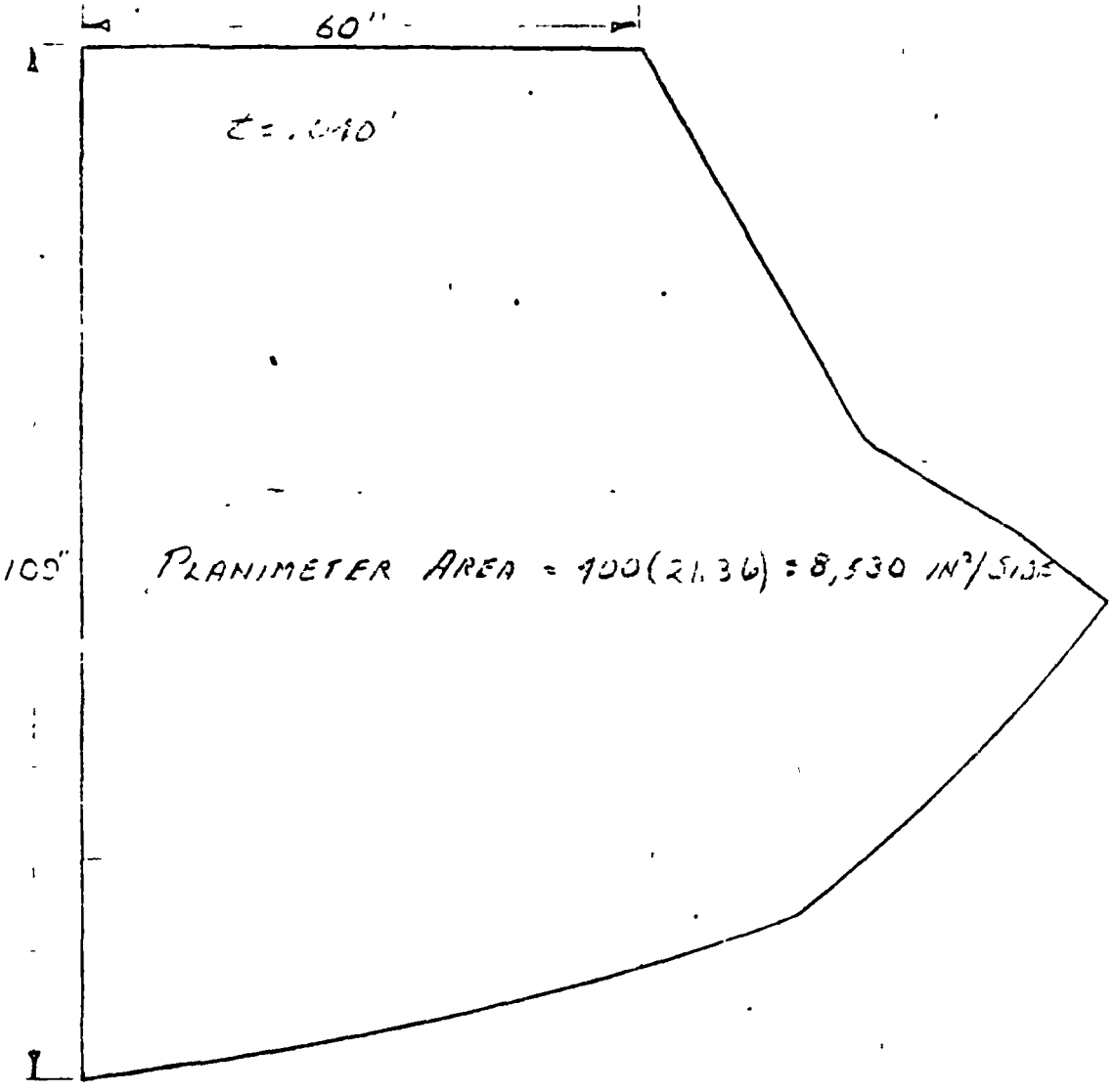
CENTER TRUSS - LOAD PICKUP FITTING

FITTING WILL BE MACHINED ON LAUNCH LOAD DISTRIBUTION LONGERON.

PLANIMETER AREA = 400(.33) = 132 IN^2/SIDE

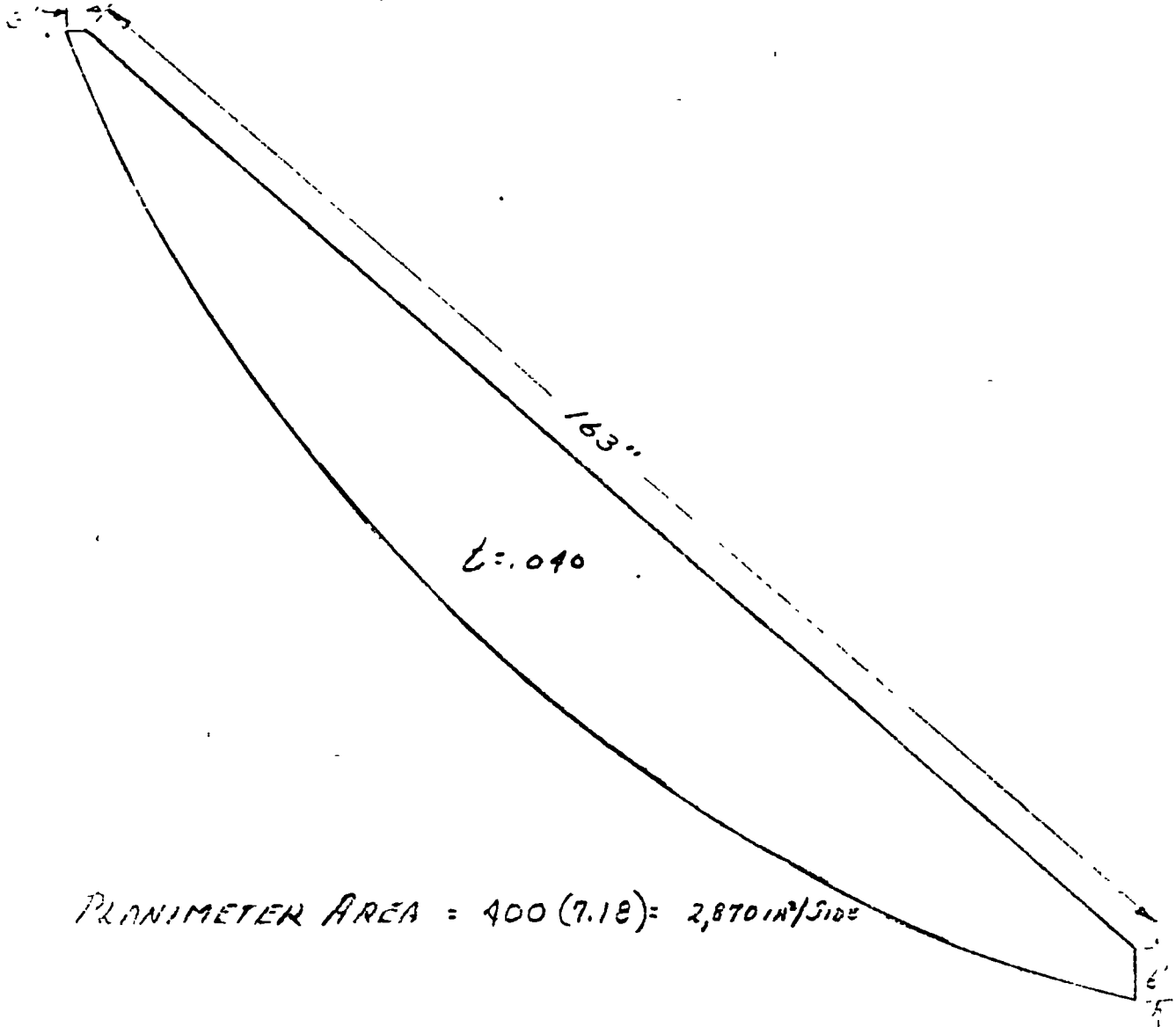
$WT = 2ALP = 2[132(3)(.101)] =$ **80 LB**

AFT PANEL - LANDING GEAR ENCLOSURE



$WT = 2ALP = 2[8,530(.040)(.101)] = 69$ LB

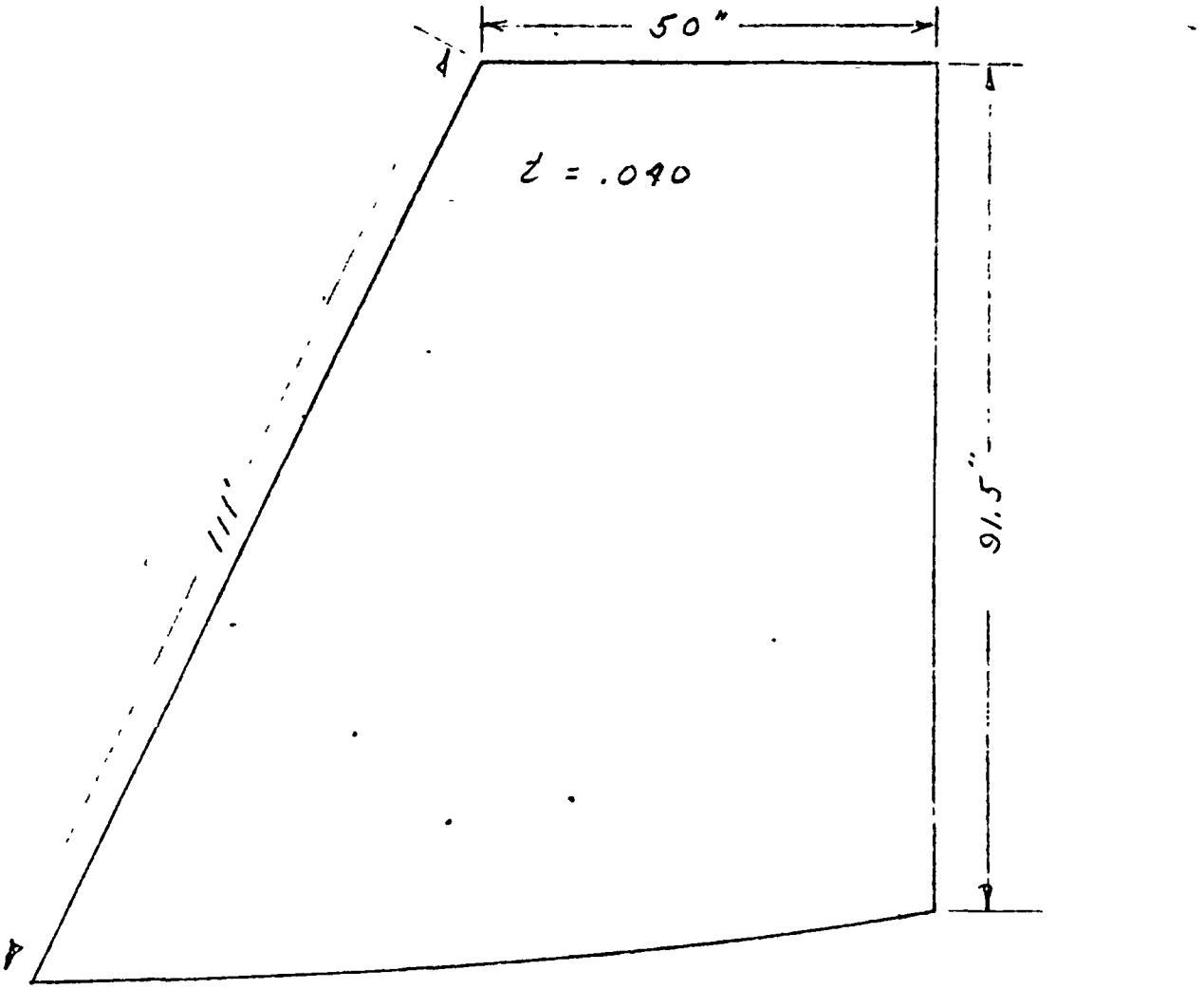
FWD PANEL - LANDING GEAR ENCLOSURE



PLANIMETER AREA = 400 (7.18) = 2,870 IN²/SIDE

WT = 2 A t ρ = 2 [2,870 (.040)(.101) = 12 LB

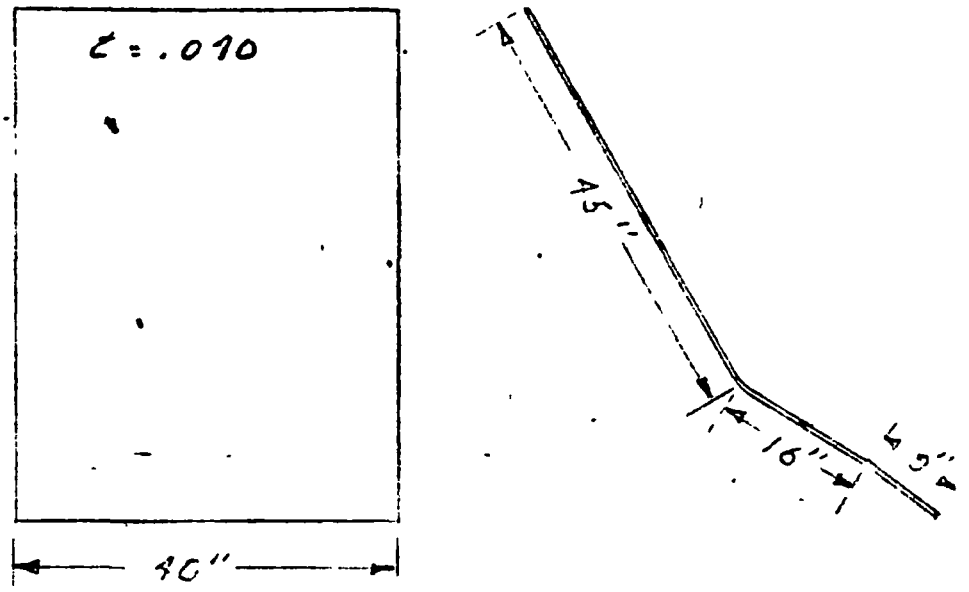
I.B. BOARD PANEL - LANDING GEAR ENCLOSURE



PLANIMETER AREA = 400 (17.9) = 7,160 IN²/SIDE

WT = 2ALρ = 2[7,160 (.040)(.101)] = 58 LB

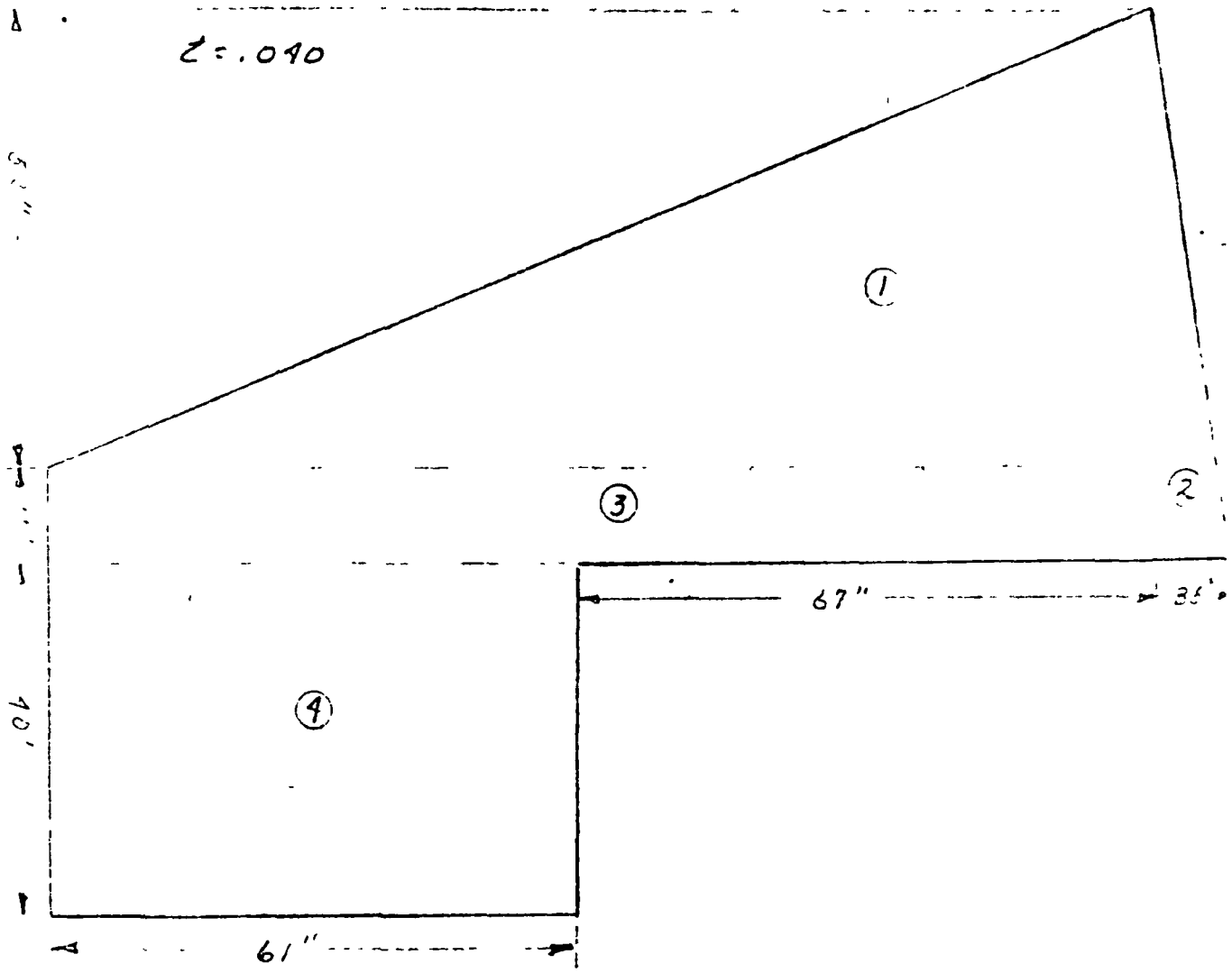
TOP PANEL, NET OUTBOARD - LANDING GEAR ENCLOSURE



AREA = 40(70) = 2,800 IN²/SIDE

WT = 2ALρ = 2[2,800(.040)(.101)] = 24 LB

TOP PANEL, FLAT SECTION - LANDING GEAR ENCLOSURE

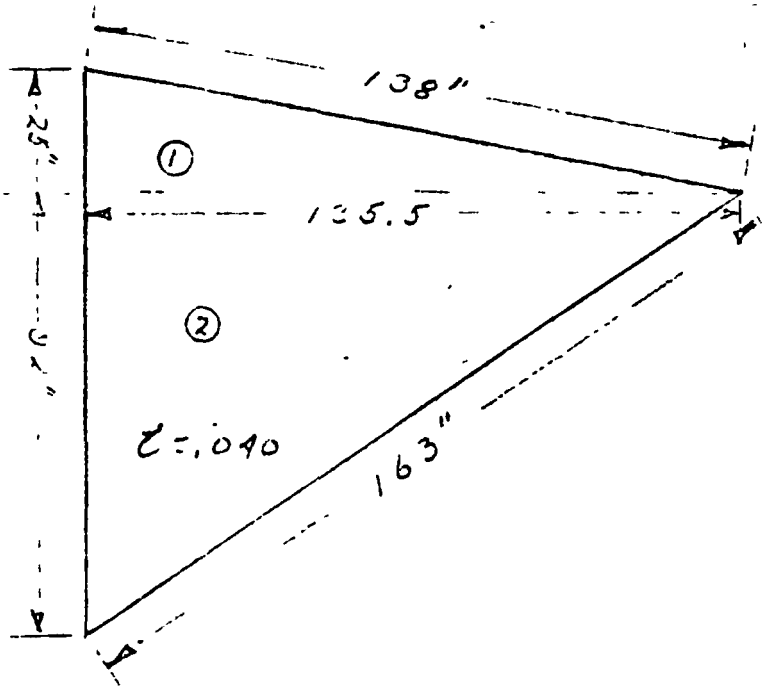


AREA:

①	$A = \frac{1}{2} bh = 64(52)$	=	3,330
②	$A = \frac{1}{2} Lh = 1.25(63)$	=	268
③	$A = WL = 11(128)$	=	1,410
④	$A = WL = 40(61)$	=	2,440
	TOTAL AREA	=	7,448 IN²/SIDE

$WT = \Lambda L \rho = 2[7,448(.040)(.101)] =$ 62 LB

TOP PANEL, SKIRTED - LANDING GEAR ENCLOSURE



AREA:

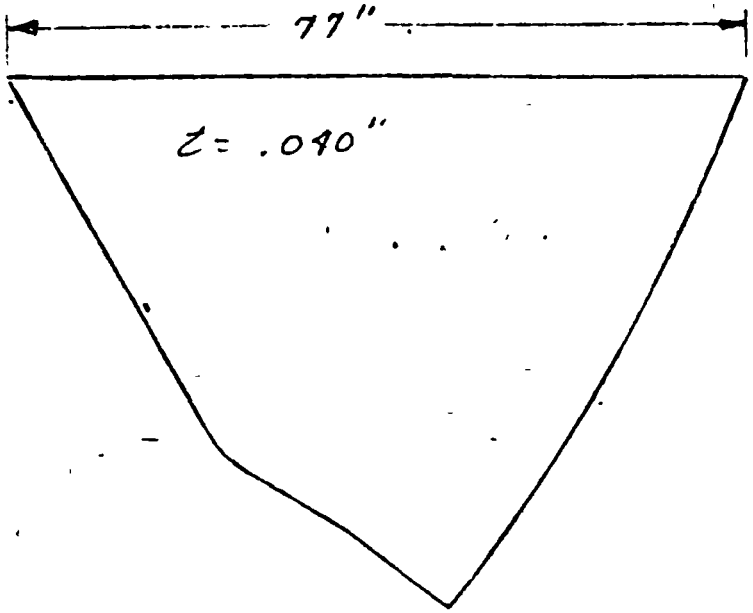
① $A = 125(135.5) = 16,95 \text{ IN}^2$

② $A = 46(135.5) = 6,230 \text{ IN}^2$

TOTAL AREA = $7,925 \text{ IN}^2/\text{SIDE}$

$Wt = 2A\ell\rho = 2[7,925(.040)(.101)] = 64 \text{ LB}$

AFT PANEL SECTION STA 3668 - LANDING GEAR ENCLOSURE



PERIMETER AREA = 4(0)(6.23) = 2490 IN²/SIDE

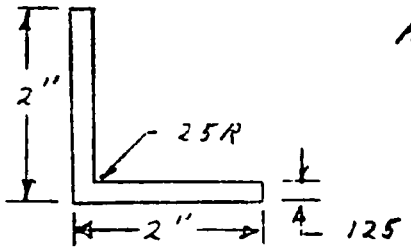
WT = 2 [2,490 (.040)(.101)] = 21 LB

GEAR WELL ENCLOSURE PANELS
SUMMARY

TOTAL WT = 69 + 12 + 58 + 24 + 62 + 64 + 21 =

= 310 LB

ATTACH ANGLES - LANDING GEAR ENCLOSURE



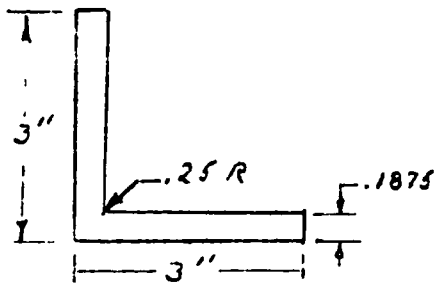
AREA = (2 + 1.875).125 + .0134 = .4984 IN²

LENGTH:

AFT PANEL - L = 55 + 77 + 121 + 89	=	342
FWD PANEL - L = 163 + 95 + 118	=	326
INBOARD PANEL - L = 117 + 50 + 93		260
TOP PANELS - L = 138 + 63 + 75 + 11	=	350
AFT PANEL - STA 362 - L = 77 + 67	=	144
INTERIOR MEMBERS - L = 24 + 60 + 50	=	134
TOTAL LENGTH	=	1,556 IN/SIDE

WT = 2ALP = 2[.4984(1,556)(.101)] = **157 LB**

STIFFENER - LANDING GEAR ENCLOSURE



AREA:
A = (3 + 2.6175)(1875) + .0134 = 1.1039 IN²

LENGTH REQ: L = 93 + 95 + 77 + 73 + 63 + 77 = 478 IN/SIDE

WT = 2ALP = 2[1.1039(478)(.101)] = **107 LB**

WT. PENALTY FOR ADDING DOOR IN ONE WHEELWELL

DOOR FRAME

FRAME IS MADE FROM SAME ANGLE USED FOR STIFFENER. HOWEVER, 1 VERTICAL MEMBER EXISTS AS A STIFFENER, AND THE OTHER VERTICAL MEMBER REPLACES AN ATTACH ANGLE

WT - HORIZONTAL MEMBER = ALP = 1.1039(40)(101) = 4.5 LB

WT - VERTICAL MEMBER = ALP = (1.1039 - .4984)(93)(.101) = 5.7 LB

DOOR PANEL

DOOR PANEL CONSISTS OF 2 0.040" SHEETS BEADED & SPOT WELDED TOGETHER ONE SHEET EXISTS AS PART OF THE INBOARD PANEL THEREFORE, THE PENALTY CONSISTS OF ADDING ONE SHEET OF 0.040" - 40" WIDE & 65" LONG

WT = 40(65)(.040)(.101) = 1.1 LB

HINGE

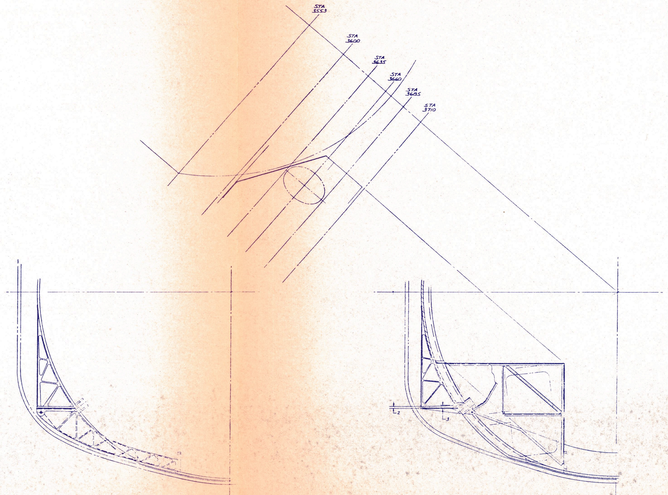
ASSUME PIANO HINGE @ .03 LB/INCH

WT = 65(.03) = 2.0 LB

FASTENERS

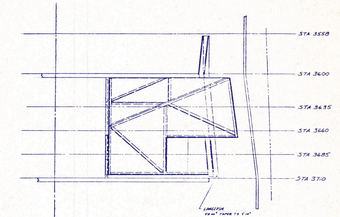
FIVE @ 03 LB EACH .2 LB

TOTAL DOOR WT PENALTY **14 LB**

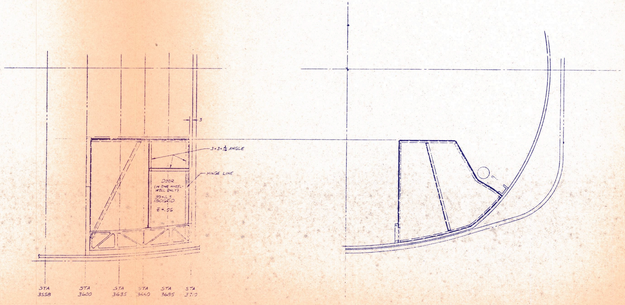


SECTION D-D
LOOKING FWD FROM STA OF STA 3635

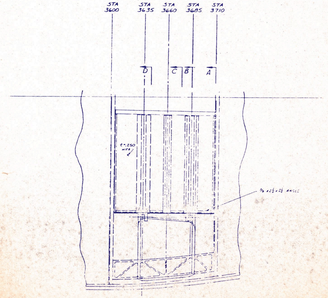
SECTION C-C
LOOKING FWD FROM STA OF STA 3660 SHOWING STA 3685 AND STA 3690



SECTION B-B
LOOKING FWD FROM STA 3685

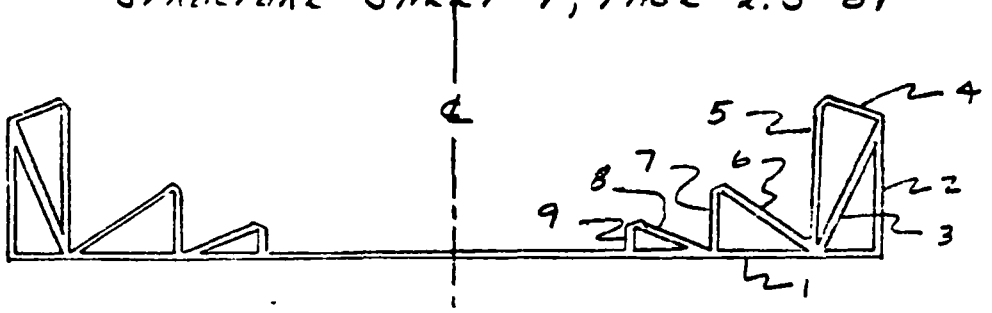


SECTION A-A
LOOKING FWD FROM STA 3710



VIEW LOOKING INBOARD

INTERTANK STRUCTURE - CANARD CARRY-THRU
AT STATIONS 1953 & 2053
SEE DRAWING NO. 256-20-0017, INTERTANK
STRUCTURE - SHEET 1, PAGE 2.3-81



AT FWD FRAME - STA. 1953			
A*	AREA (IN²)	LENGTH (IN)	WT (lb)
1	1.9	162	29.2
2	.9	55	5.0
3	.9	58	5.2
4	.9	20	1.8
5	.9	57	5.1
6	.9	46	4.1
7	.9	25	2.2
8	.9	30	2.7
9	.9	11	1.0

TOTAL 57.3 (2 REQ)

AT FWD FRAME 114.6 lb

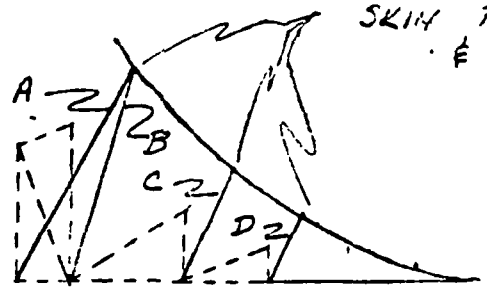
AT AFT FRAME - STA. 2053			
A*	AREA (IN²)	LENGTH (IN)	WT. (lb)
1	6.5	162	105.2
2	1.3	55	7.2
3	1.3	58	7.5
4	1.3	20	2.6
5	1.3	57	7.4
6	1.3	46	6.0
7	1.3	25	3.2
8	1.3	30	3.9
9	1.3	11	1.4

TOTAL 144.4 (2 REQ)

AT AFT FRAME 299.2 lb.

INTERTANK STRUCTURE - CANARD CARRY-THRU

STABILIZING MEMBERS FOR TRUSSES AT STA. 1953 & 2113



MEMBER A

LENGTH = $\sqrt{60^2 + 30^2} = \sqrt{4500} = 67$ IN.

MEMBER B

LENGTH = $\sqrt{57^2 + 30^2} = \sqrt{4150} = 64$ IN.

MEMBER C

LENGTH = $\sqrt{25^2 + 30^2} = 39$ IN.

MEMBER D

LENGTH = $\sqrt{11^2 + 30^2} = 32$ IN.

MEMBER	LENGTH (IN)	AREA IN^2	WT. lb.
A	67	.9	6.0
B	64	.9	5.8
C	39	.9	3.5
D	32	.9	2.9

TOTAL 18.2 (4 REQ)

72.8 lb.

MEMBER TERMINATIONS

AT THE NODAL POINTS ASSUME SIMILAR TO THOSE USED FOR MIN. STRENGTH DIAGONALS - .92 lb. EACH

AT STA. 1953 & 2093 ASSUME SIMILAR TO JOINT OF INNER CAP. AND CANTED DIAGONAL - .95 lb EACH

16 REQ × (.92 + .95) = 16 × 1.87 = 29.9 lb.

TOTAL WT. = 72.8 + 29.9 = **102.7 lb.**

SHEAR PANEL FOR CANARD ATTACH LOAD - 2 REQ

PANEL IS ATTACHED ON TOP OF CANARD ATTACH FRAMES BETWEEN STA 1953 & 2093 AND IS 19 INCHES WIDE

ISOGRID PANEL WITH $\bar{t} = 0.10"$

AREA = 140 (19) = 2,660 IN^2/SIDE

$WT = 2 A \bar{t} \rho = 2[2,660(.10)(.101)] =$ **54 LB**

WING LEADING EDGE ATTACHMENT

· 4 FINGER SECTION

		VOL (IN^3)
$V_1 =$	$\frac{1}{2}(7.3+3.7)(5.5)(.9)$	= 27.2
$V_2 =$	$-.785(.9)^2 \times 8 \times 3$	= -17
$V_3 =$	$(.6)(75)(10)$	= 4.5
$V_4 =$	$(1.0)(.9) \times 1.2 \times 5$ $+[(1.2)(1.0) \times 2 + (1.0)(1.0) \times 2][.3]$	= 2.9
$V_5 =$	$(39.8 + 38.0 \times 2 + 39.6)(2.15\ in^2)$	= 334.1
$V_6 =$	$[(2.5)(3.8)(3.5) - .785(1.7)^2(2)$ $- .785(3.0)^2(5)] \times 4$	= 101.2
$V_7 =$	$[(3.1)(3.5)(1.1) - .785(1.75)^2(1.1)] \times 4$	= 37.1
$V_8 =$	$\{(3)(28.7)(1.8) + (.3)(27.8)(1.8)$ $+[\frac{1}{2}(1.5)(.9) + \frac{1}{2}(10)(.5)][1.8]\} \times 2$	= 64.4
$V_9 =$	$(210 + 300)(.3)(1.9) \times 2$	= 55.1
$V_{10} =$	$[(14)(1.2) + (16.2)(1.4) + (7.2)(1.1) + \frac{1}{2}(2)(1.2)$ $+\frac{1}{2}(2.6)(13) + (6.0)(1.4) + (40)(1.2) + (5.7)(1.4)$ $+ (8.3)(1.2) + (1.1)(1.4)][.35] \times 2$	= 58.3
V_{11} (FILLETS)	$= .246(.25)^2 \times 300$ in	= 4.0
	V_T	= 687.1

(MAT'L ALUMINUM)

WT = $(687.1\ in^3)(.101\ LB/in^3)$ = 69.4 LBS 2 REQ

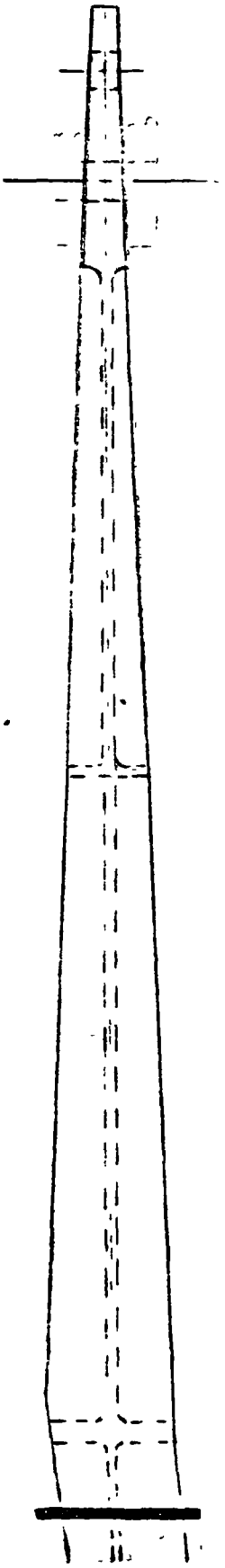
TOTAL WT = 2(69.4) = **140 LB**

WING LEADING EDGE ATTACHMENT

4 FINGER SECTION

REF DRWG 156-20-0007

SIDE VIEW



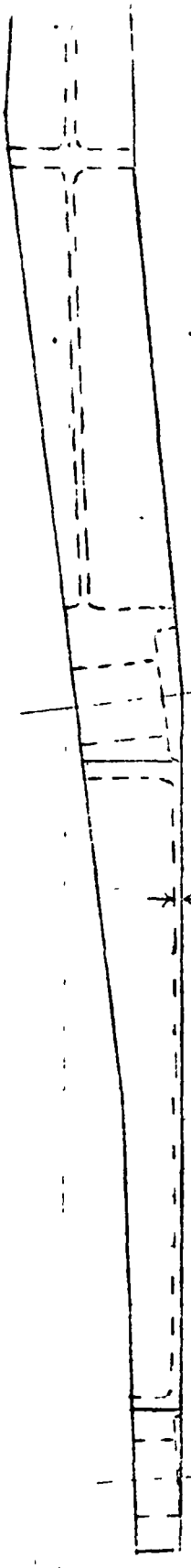
APPROX 1/4 SCALE

WING LEADING EDGE ATTACHMENT

REF.
DRWG 256-20-0007

4 FINGER SECTION

SIDE VIEW



USE 0.35"t (AVG)
PER D. HUNT

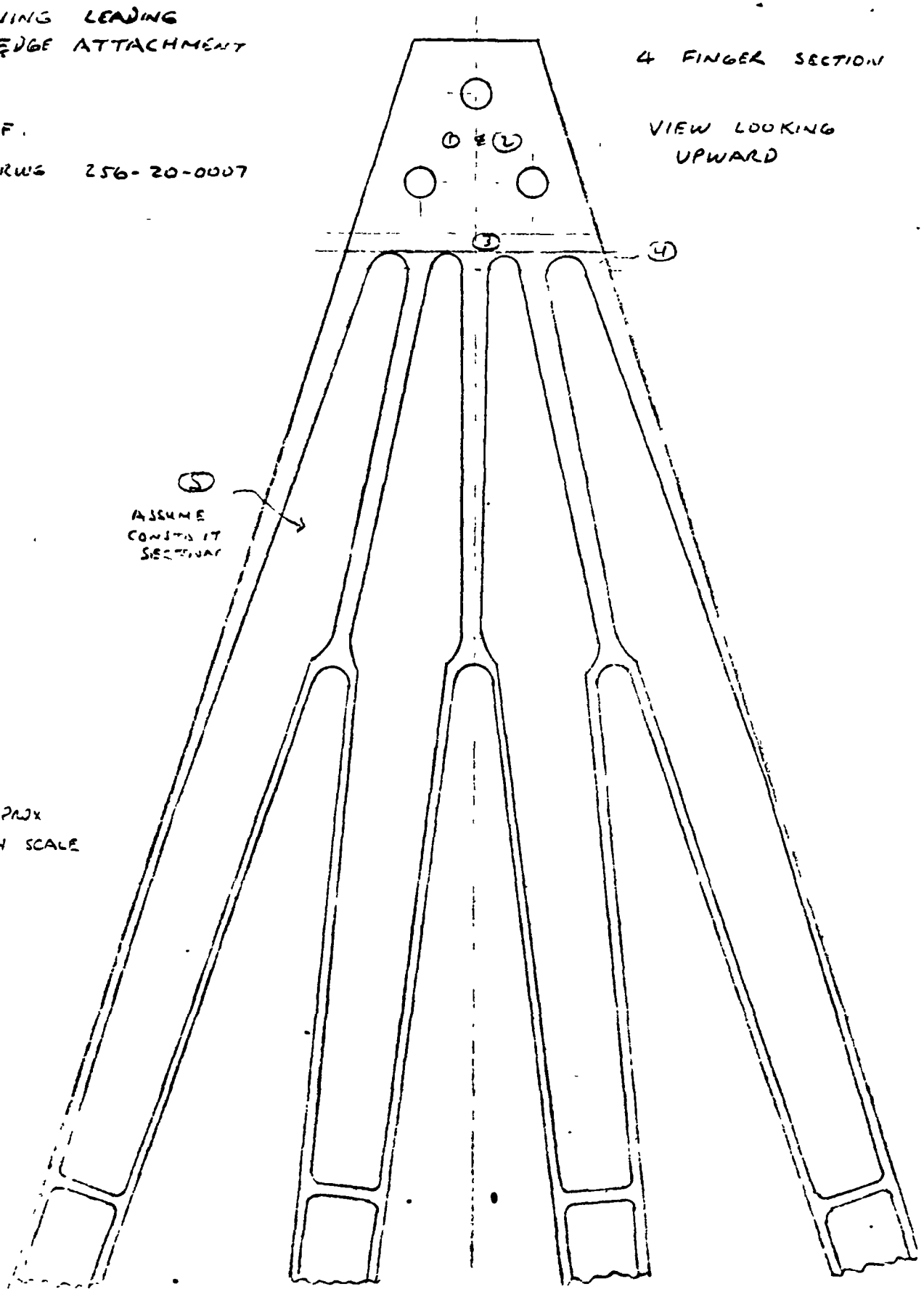
APPROX 1/4 SCALE

WING LEADING EDGE ATTACHMENT

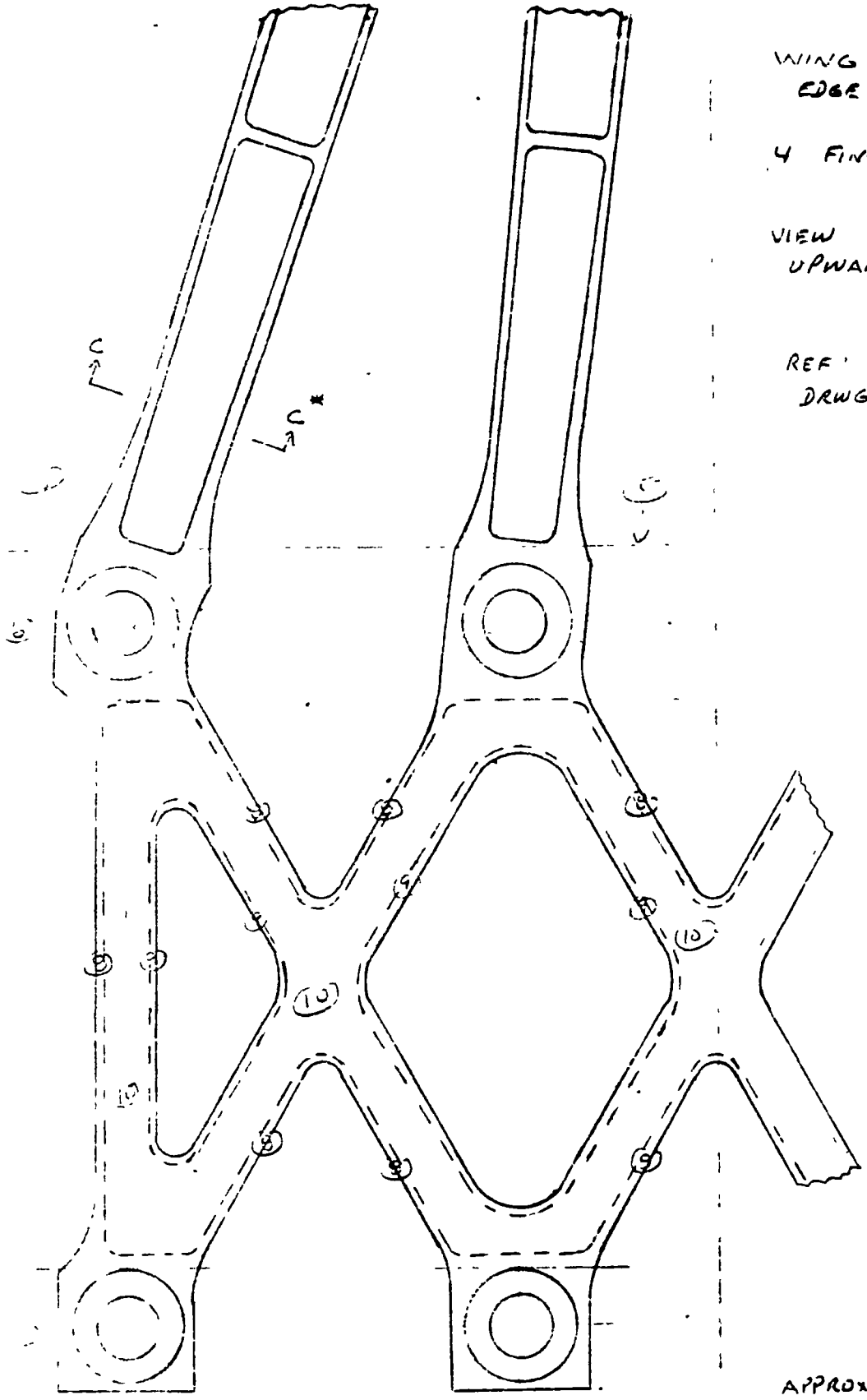
REF. DRWG 256-20-0007

4 FINGER SECTION

VIEW LOOKING UPWARD



APPROX 1/4 SCALE



WING LEADING EDGE ATTACHMENT

4 FINGER SECTION

VIEW LOOKING UPWARD

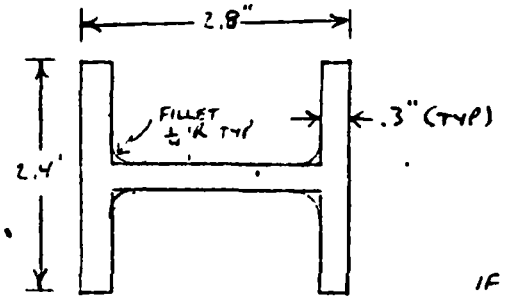
REF:
DRWG 256-20-0007

APPROX 1/4 SCALE

* ASSUME TYPICAL SECTION
SEE PAGE 3.

WING LEADING EDGE ATTACHMENT

4 FINGER SECTION



SECTION C-C

ASSUME TYPICAL

$A_1 = (2.4)(.3) \times 2 + (2.2)(.3)$

$A_1 = 2.10\ IN^2$

IF FILLETS = 3/8" R

$A_2 = 2.146(.375)^2 \times 4 = .12\ IN^2$

IF FILLETS = 1/4 R

$A_2 = .2146(.25)^2 \times 4 = .05\ IN^2$

ASSUME FILLETS = 1/4" R

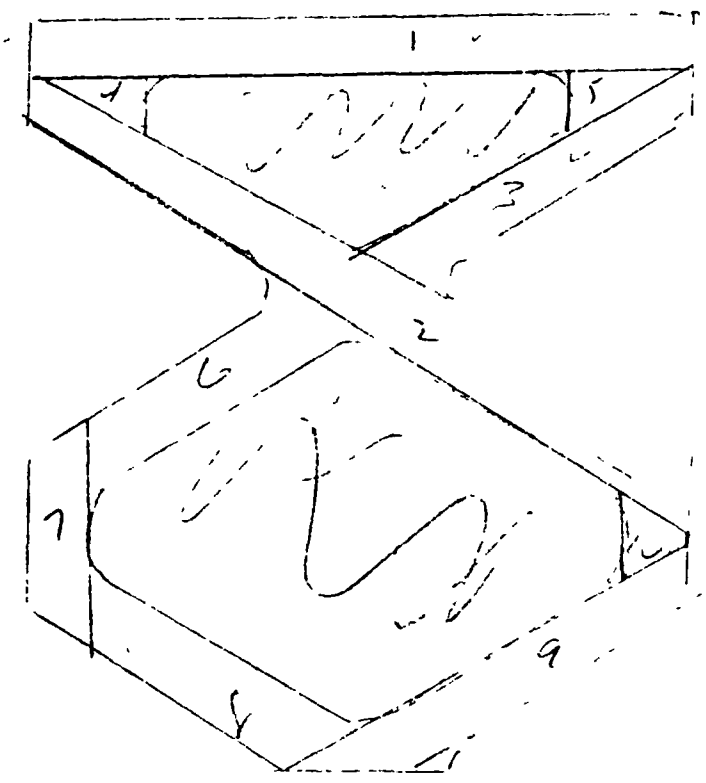
$A = 2.10\ IN^2 + .05\ IN^2 = \underline{2.15\ IN^2}$

INFORMATION PER D. HUNT

WING LEADING EDGE ATTACHMENT

4 FINGER SECTION

VOLUME # 10



WING LEADING EDGE ATTACHMENT

2 FINGER SECTION

		VOL (IN^3)
$V_1 = \frac{1}{2}(3+9)(7.2)(4.0) - .785(10)^2(.3) - .785(5)^2(.6) \times 2$	=	16.9
$V_2 = [(.8)(2.5) \times 2 + \frac{1}{2}(4)(4.0) \times 4][1.0] + \frac{1}{2}(1.5+1.2)(2.5)(.25) \times 2$	=	8.0
$V_3 = (36.2 \times 2 \times 1.83\ IN^2)$	=	132.5
$V_4 = [(3.5)(4.0)(2.4) - .785(1.75)^2 \times 2.0 - .785(3.0)^2 \times .55][2]$	=	55.4
$V_5 = [(3.5)(3.5)(1.2) - .785(1.6)^2 \times 1.1][2]$	=	25.0
$V_6 = (52.0)(1.2)(.25) + \frac{1}{2}(10)(1.4)(1.8) \times 4$	=	28.4
$V_7 = (21.0+21.0)(1.8)(.25)$	=	18.9
$V_8 = [(11)(14) - \frac{1}{2}(8+17.0)(5.0) \times 2 - \frac{1}{2}(.6+9.0)(2.3) \times 2 - (9.0)(1.0) \times 2][.25]$	=	74.9
V_9 (FILLETS). EST $= 2\pi(.25)^2 \times 150\ IN$	=	2.0
V_T =	=	362.0

(MAT'L ALUMINUM)

$WT = (362.0\ IN^3)(.101\ LB/IN^3) =$ 36.6 LBS 2 REQ

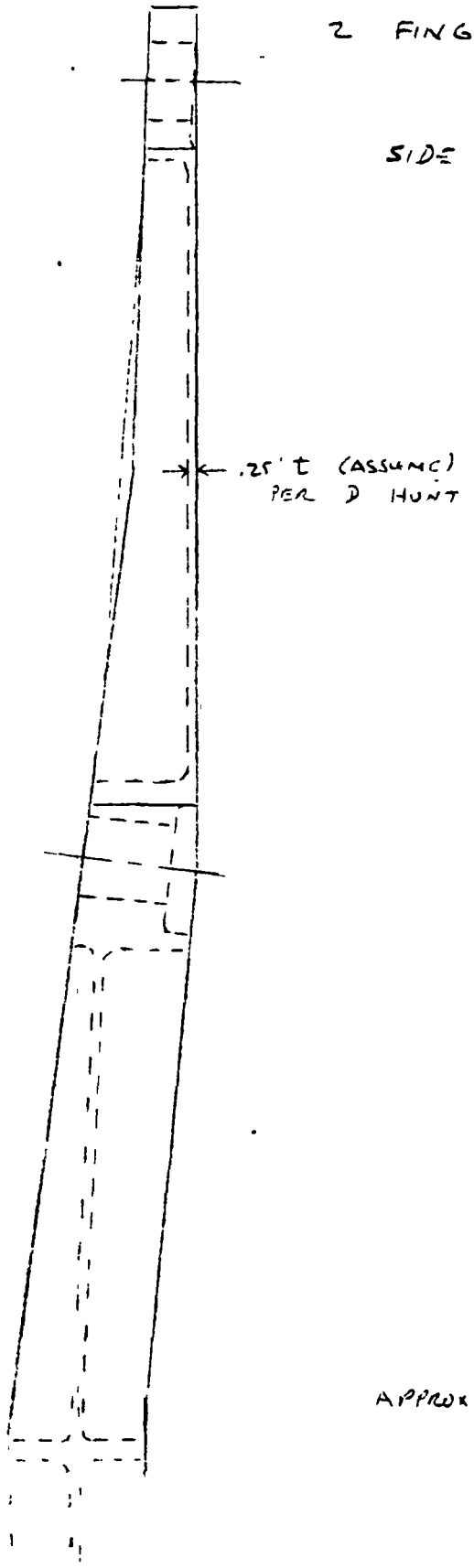
TOTAL WT = 2(36.6) = **74 LB**

WING LEADING EDGE ATTACHMENT

REF DRWG 256-20-0007

2 FINGER SECTION

SIDE VIEW



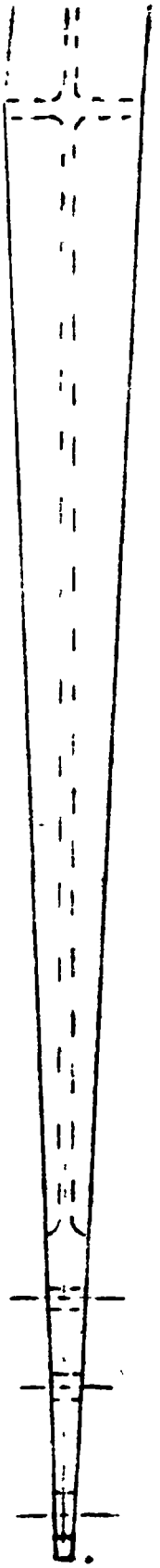
APPROX V/V SCALE

WING LEADING EDGE ATTACHMENT

REF. DRWG 256-20-0007

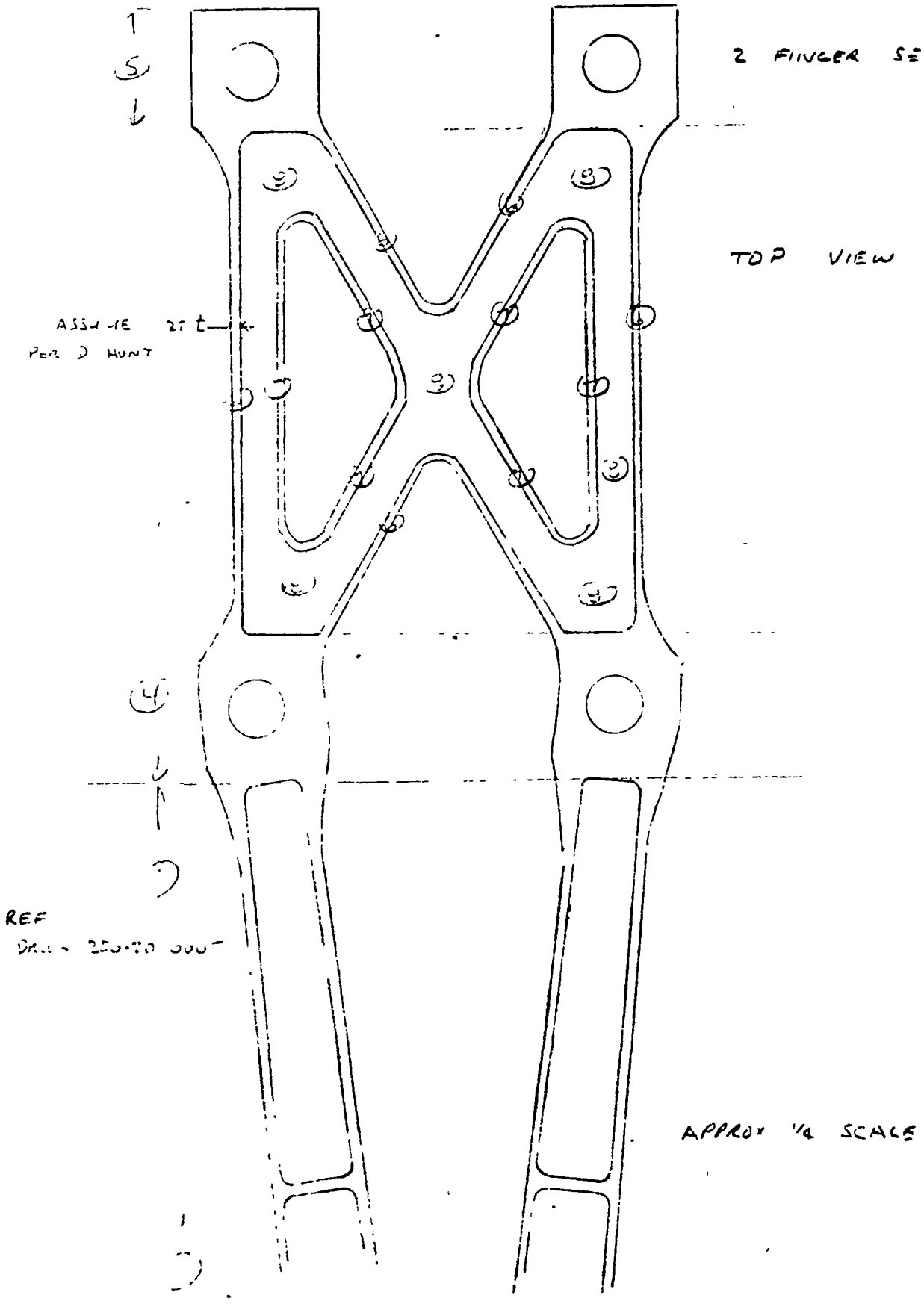
2 FINGER SECTION

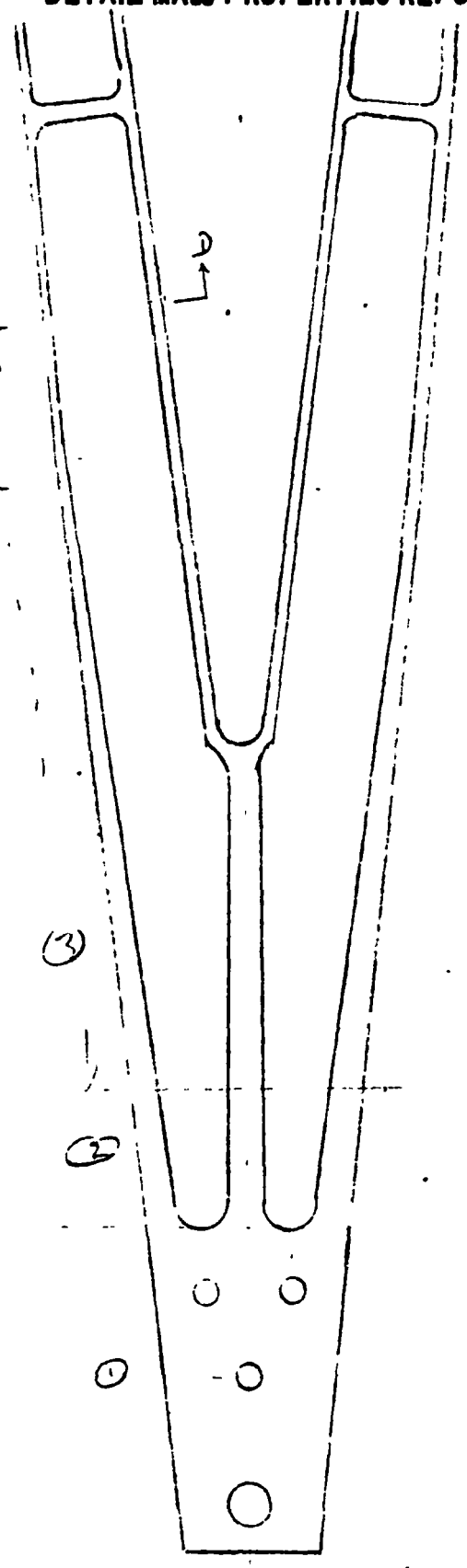
SIDE VIEW



APPROX 1/4 SCALE

WING LEADING EDGE ATTACHMENT

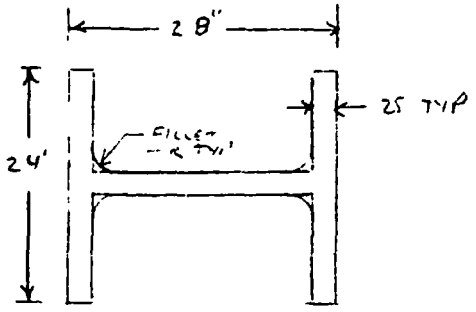




* ASSUME TYPICAL SECTION
SEE PAGE 2

WING LEADING EDGE ATTACHMENT

2 FINGER SECTION



SECTION D-D

ASSUME TYPICAL

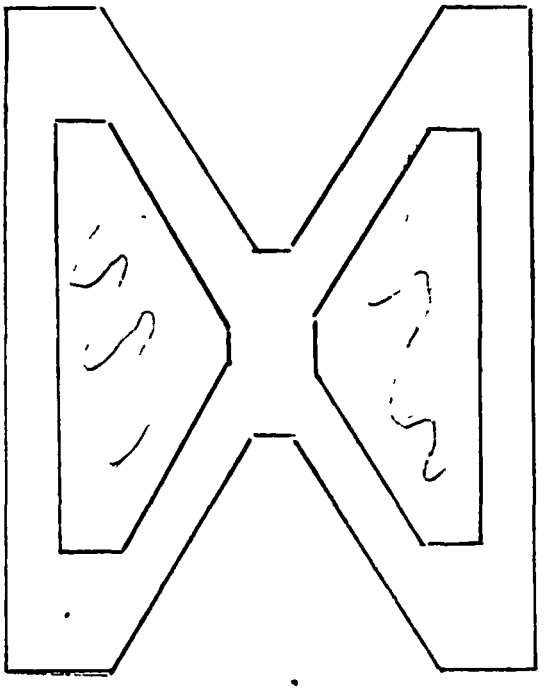
$A_1 = (2.4(.2) \times 2 - (2.3)(.25)) = 1.78\ in^2$

A_2 (ASSUME FILLETS ¼" R):
$= .2146(.25)^2 \times 4 = .05\ in^2$

$A_T = 1.83\ in^2$

INFORMATION PER D HUNT

WING LEADING EDGE ATTACHMENT
2 FINGER SECTION

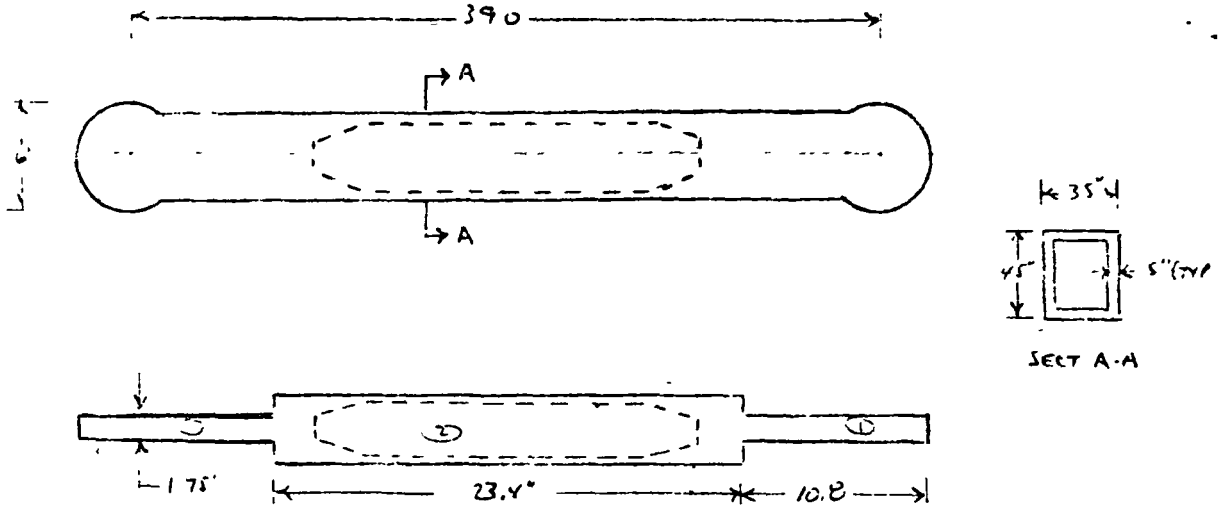


VOLUME No. 8

APPROX 1/4 SCALE

WING LEADING EDGE ATTACHMENT

STRUT



① $V_1 = [.785(6.0)^2 + (5.8)(4.5)][1.75] \times 2 = 190\ IN^3$

② $V_2 = [(4.5)(3.5) - (3.5)(2.5) + .2146(.25)^2 \times 4] [23.4] = 165\ IN^3$

$V_T = 355\ IN^3$

MATERIAL ALUMINUM

$WT = (355\ IN^3)(.101\ LB/IN^3) = 35.9\ LBS$ 2 REQ

TOTAL WT = 2(35.9) ≃ **72 LB**

INFORMATION PER: D. HUNT.

WING LEADING EDGE ATTACHMENT

FITTING ① 2 REQ

$V_1 = (6)(5)(.8) = 24.0\ IN^3$

$V_2 = (2.0)(.9)(4.5) = 8.1\ IN^3$

$V_3 = (.5)(70)(3.75) = 13.1\ IN^3$

$V_4 = [1/2(.3+1.7)(6.5) + 1/2(.8+1.5)(1.5)][.8] = 6.6\ IN^3$

TOTAL VOLUME = $51.8\ IN^3$

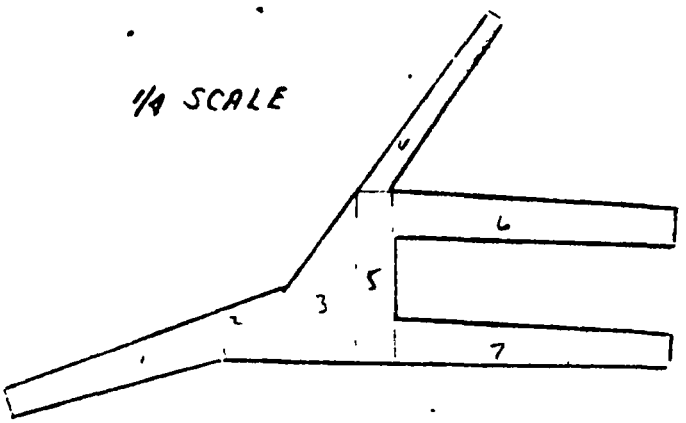
MATERIAL: STEEL

$WT = 2(51.8)(.286) \simeq$ **30 LB**

FITTING ② 2 REQ

MATERIAL: STEEL

1/4 SCALE



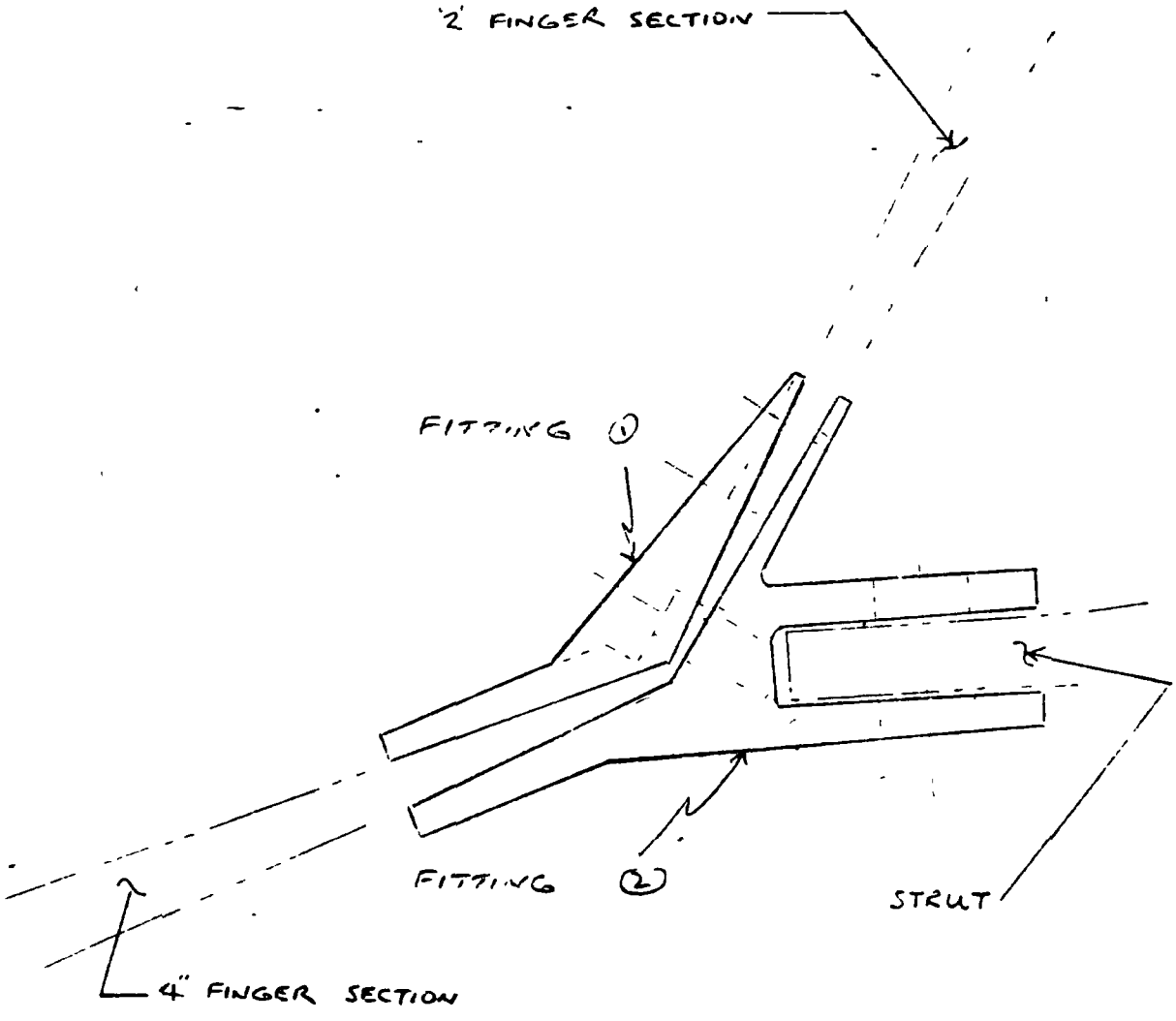
①	A = (4.6)(.8)	=	3.7
②	A = 1/2(16)(10)	=	0.8
③	A = 1/2(27)(3.6)	=	4.9
④	A = (46)(.5)	=	2.3
⑤	A = (36)(.8)	=	2.9
⑥	A = (6.0)(.9)	=	5.4
⑦	A = (5.3)(.9)	=	4.9

$A_T = 24.9\ IN^2$

$WT = 2(24.9)(5.0)(.286) =$ **72 LB**

WING LEADING EDGE ATTACHMENT

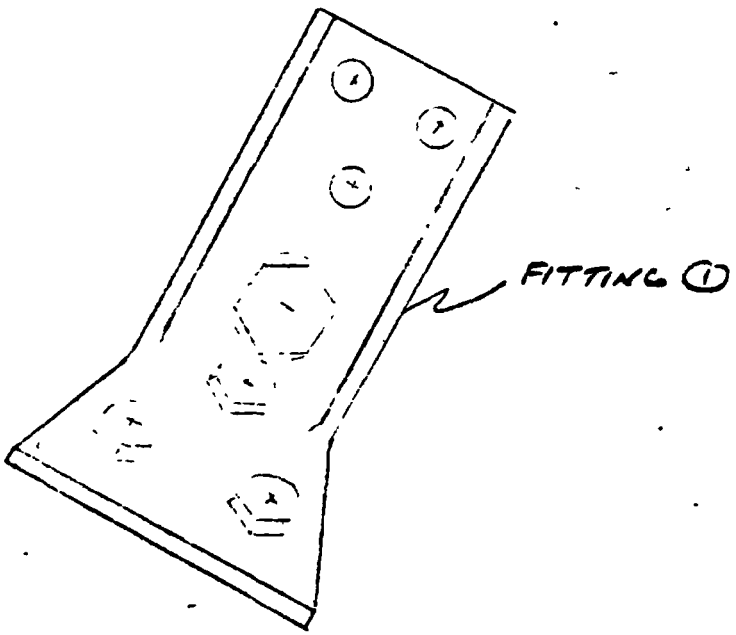
REF: DRWG 256-20-0007

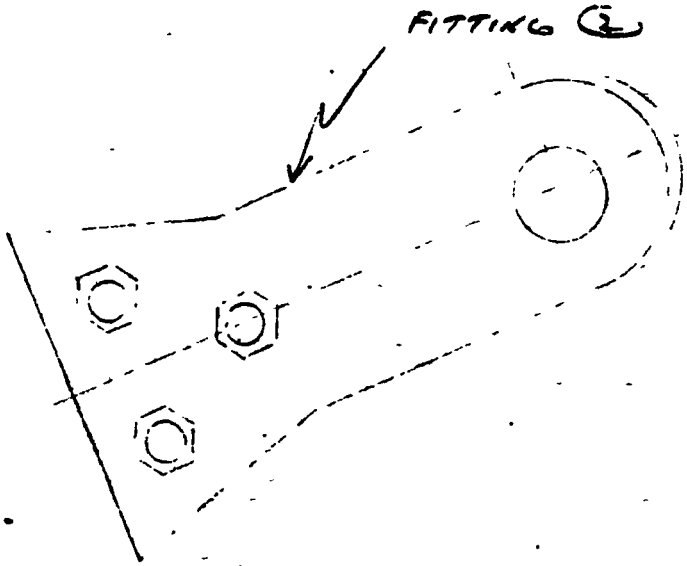


APPROX 1/4 SCALE

WING LEADING EDGE ATTACHMENT

REF: DRWG 256-20-0007





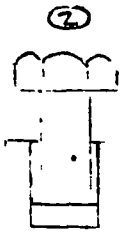
APPROX 1/6 SCALE

WING LEADING EDGE ATTACHMENT

ATTACHING PARTS AT FITTING ① & FITTING ②

3 REQ PER SIDE

GRIP LENGTH = 3.75
DIA = 7/8"

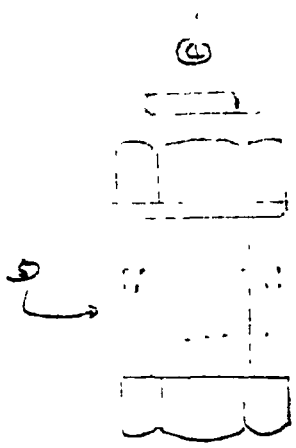


1 REQ PER SIDE

GRIP LENGTH = 3
DIA = 1.0"

3 REQ PER SIDE

GRIP LENGTH = 2.25
DIA = .5"



1 REQ PER SIDE

GRIP LENGTH = 6.0"
DIA = 2.0"

① BOLT
$V = .785(.975)^2(3.75) + .866(1.0)^2(6) = 3.01$
NUT
$V = [.866(1.2)^2 - .785(.975)^2][.8] = .52$
3.53

② BOLT
$V = .785(1.0)^2(3.0) + .866(1.8)^2(.9) = 4.89$
SLEEVE NUT
$V = (.785(1.1)^2 - .785(1.0)^2][2.0] = 1.50$
6.39

③ BOLT
$V = .785(.5)^2(2.25) + .866(.9)^2(.5) = .79$
NUT
$V = [.866(.9)^2 - .785(.5)^2][.6] = .30$
1.09

④ BOLT
$V = .785(2.0)^2(6.0) + .866(2.6)^2(1.2) = 25.98$
NUT
$V = [.866(2.6)^2 - .785(2.0)^2][2.1] = 5.71$
31.59

$V_{①} = 3.53\ in^3 \times 3 = 10.6$
$V_{②} = 6.39\ in^3 \times 1 = 6.4$
$V_{③} = 1.09\ in^3 \times 3 = 3.3$
$V_{④} = 31.59\ in^3 \times 1 = 31.6$

$V_T = 51.9\ in^3$

ASSUME MATERIAL STEEL (.291 LB/IN³)

BOLT & NUT WT = $(51.9\ in^3 \times .291\ LB/in^3) = 15.1$ LBS

⑤ RETAINER WT = $.785[(3.0)^2 - (2.41)^2][1.0][.291] \times 2 = 3.8$ LBS

TOTAL WT PER SIDE = 18.9 LBS

1/4 SCALE

ASSUME 20 LBS/SIDE = **40 LB**

WING LEADING EDGE ATTACHMENT

SPECIAL PLUG INSERT
FOR "4" FINGER SECTION & "2" FINGER SECTION

REF DRWG 256-20-0007 & 256-20-0006

SPECIAL PLUG MADE UP OF 5 PARTS
(SEE FOLLOWING SHEETS) AS FOLLOWS

①	CYLINDRICAL SECTION	1.15 LBS
②	SLEEVE SECTION	.32 LBS
③	BOLT SECTION	2.13 LBS
④	PLUG SECTION	.33 LBS
⑤	WASHER SECTION	.15 LBS
	WT/EA INSERT	4.08 LBS

ASSUME WT 4.1 LBS/EA

FOR BOTH SIDES

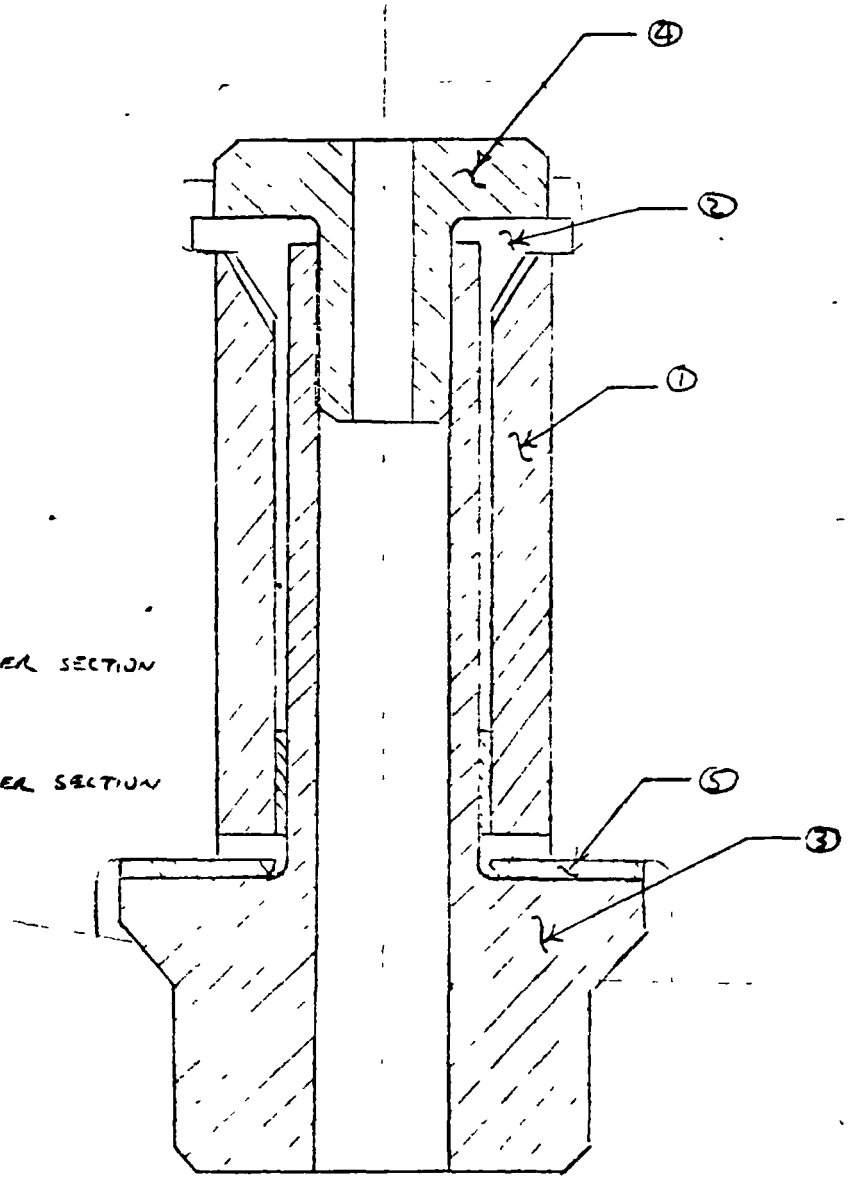
2 "4" FINGER SECTIONS 8 INSERTS/"4" FINGER SECT = 16 REQ
2 "2" FINGER SECTIONS 4 INSERTS/"2" FINGER SECT = 8 REQ

TOTAL REQUIRED = 24

WT = (4.1 LB/EA)(24) = **99 LBS**

WING LEADING EDGE ATTACHMENT

REF DRWG 256-20-0007



8 SECTIONS
PER EACH "4" FINGER SECTION

4 SECTIONS
PER EACH "2" FINGER SECTION

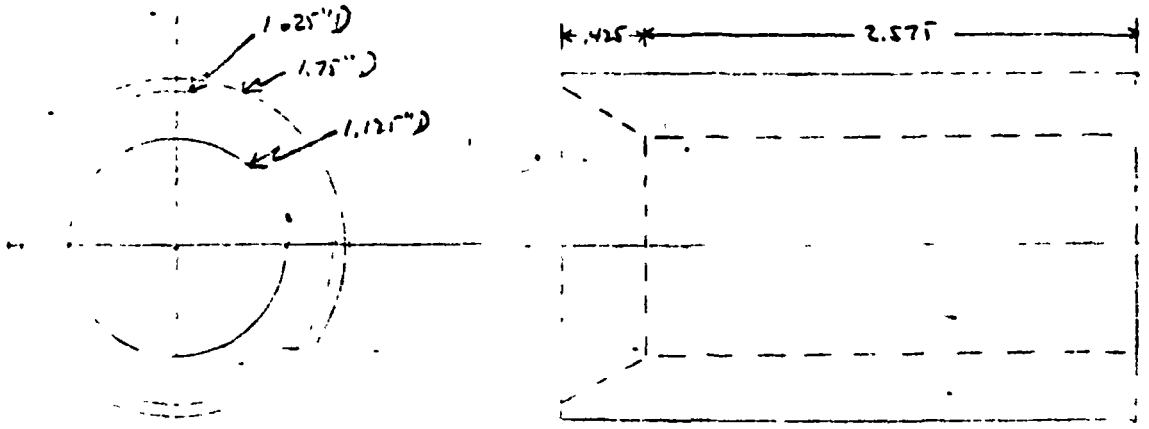
SECTION B-B

SCALE 1/1

WING LEADING EDGE ATTACHMENT

REF: DRWG NO. 256-20-0006

①



SCALE 1/1

$V_1 = .785[(1.75)^2 - (1.125)^2][2.575] = 3.63\ in^3$

$V_2 = .785(1.75)^2(.425) = 1.02\ in^3$

$V_3 = -\frac{\pi(.425)}{3}[(.812)^2 + (.812)(.562) + (.562)^2] = -.64\ in^3$

$V_T = 4.01\ in^3$

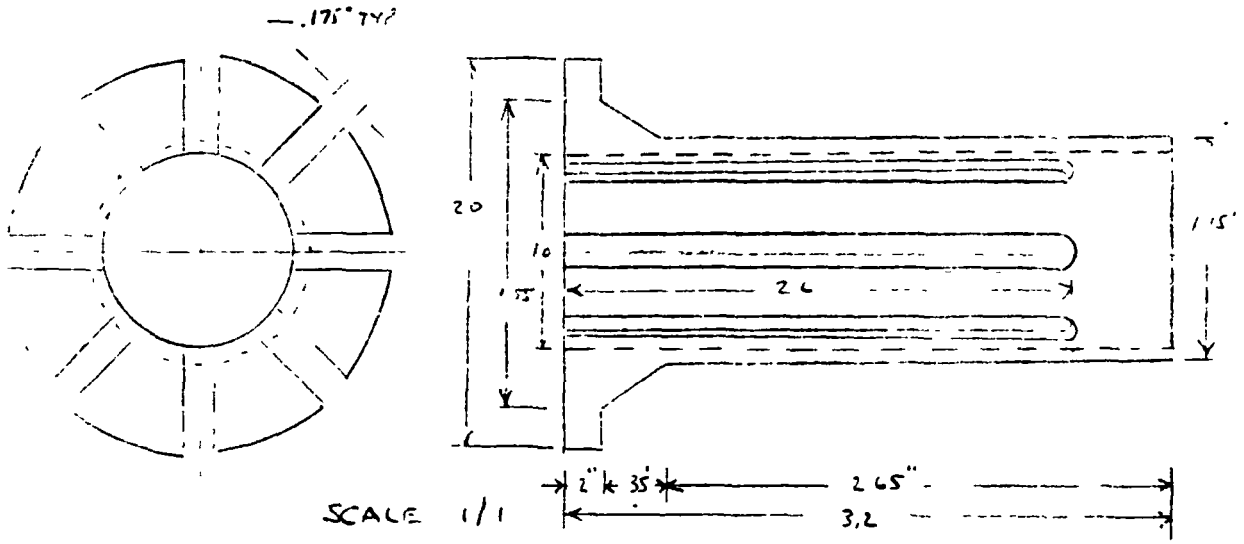
MATERIAL STEEL

$WT = (4.01\ in^3 \times .286\ lb/in^3) = \underline{1.15\ LBS}$

WING LEADING EDGE ATTACHMENT

. REF: DRWG NO. 256-20-0006

(2)



$V_1 = .785 (2.0)^2 (.2) = .63 \ IN^3$

$V_2 = \frac{\pi(.35)}{3} [(.775)^2 + (.775)(.575) + (.575)^2] = .51 \ IN^3$

$V_3 = .785 (1.15)^2 (2.65) = 2.75 \ IN^3$

$V_4 = -.785(1.0)^2 (3.2) = -2.51 \ IN^3$

$V_5 = -(.175)(2.6)(.075) \times 2 = -.27 \ IN^3$

$V_T = 1.11 \ IN^3$

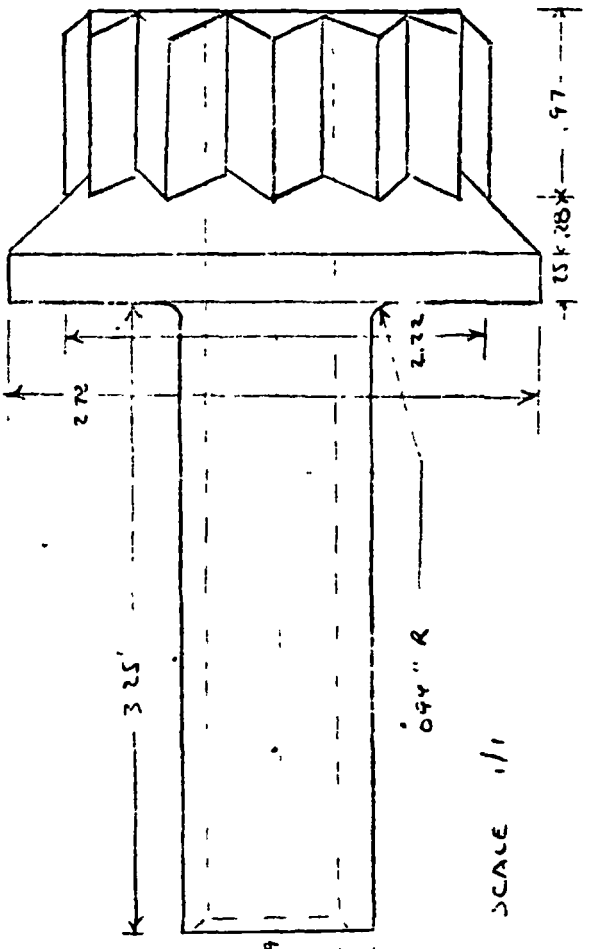
MATERIAL STEEL

$WT = (1.11 \ IN^3)(.286 \ LB/IN^3) = .32 \ LBS$

WING LEADING EDGE ATTACHMENT

REF: DRWG No. 256-20-0006

(3)



SCALE 1/1

$V_1 = .785(1.0)^2\ (3.25)$ = 2.55 IN^3

$V_2 = .785(2.79)^2\ (.25')$ = 1.52 IN^3

$V_3 = \frac{1}{2}[\pi(.28)^2][(1.39)^2+(1.39X1.11)+(1.11)^2]$ = 1.38 IN^3

$V_4 = .785\ (2.22)^2\ (.97)$ = 3.75 IN^3

$V_5 = .2146\ (.094)^2 \times 11(1.1)$ = .01 IN^3

$V_6 = -.785\ (.69)^2\ (4.75)$ = -1.77 IN^3

V_T = 7.44 IN^3

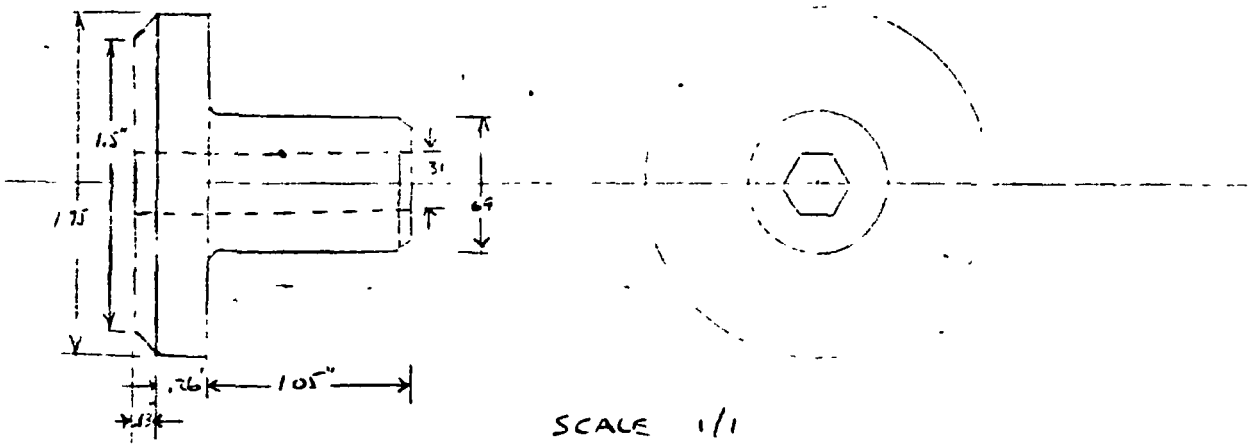
MATERIAL STEEL

$WT = (7.44\ IN^3 X .286\ LB/IN^3)$ = 2.13 LBS

WING LEADING EDGE ATTACHMENT

REF: DRWG NO. 256-20-0006

(4)



SCALE 1/1

$V_1 = \frac{\pi(.13)}{3}[(.99)^2 + (.99)(.75) + (.75)^2] = .27\ IN^3$

$V_2 = .795\ (1.75)^2\ (.26) = 63\ IN^3$

$V_3 = .795\ (.69)^2\ (1.05) = .38\ IN^3$

$V_4 = -.866\ (.31)^2\ (1.44) = -.12\ IN^3$

$V_T = 1.16\ IN^3$

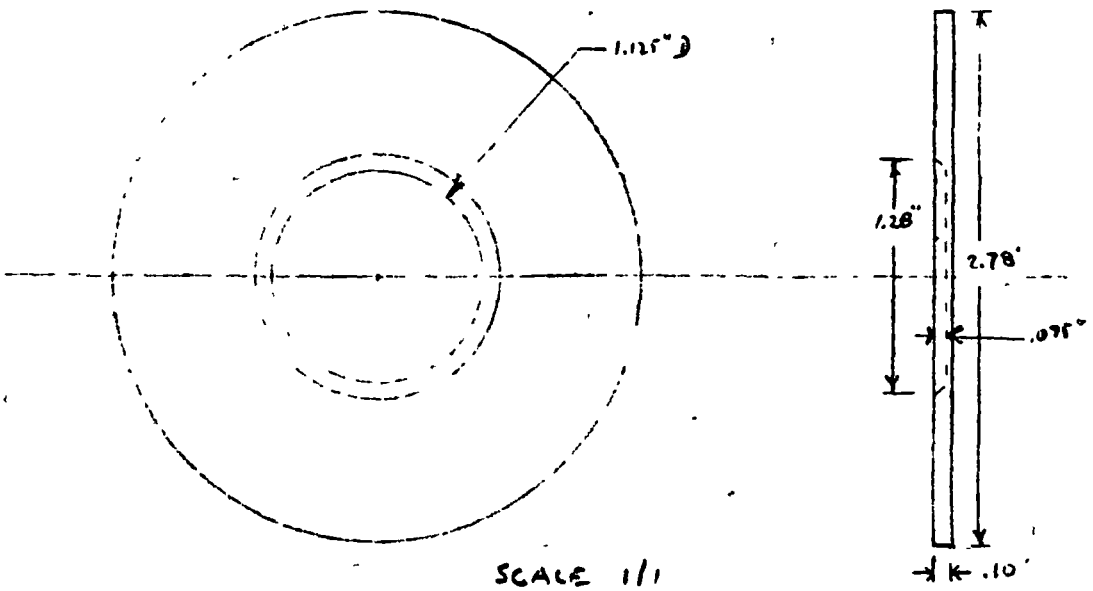
MATERIAL STEEL

$WT = (1.16\ IN^3)(.286\ LB/IN^3) = 0.33\ LBS$

WING LEADING EDGE ATTACHMENT

· REF : DRWG NO. 256-20-0006

(5)



SCALE 1/1

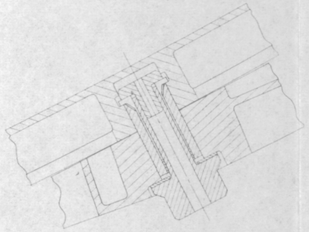
$V_1 = .785(2.79)^2(.100) = .61\ IN^3$

$V_2 = -.785(1.2)^2(.075) = -.08\ IN^3$

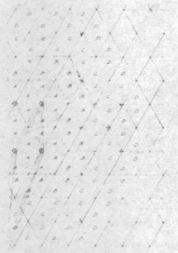
$V_T = .53\ IN^3$

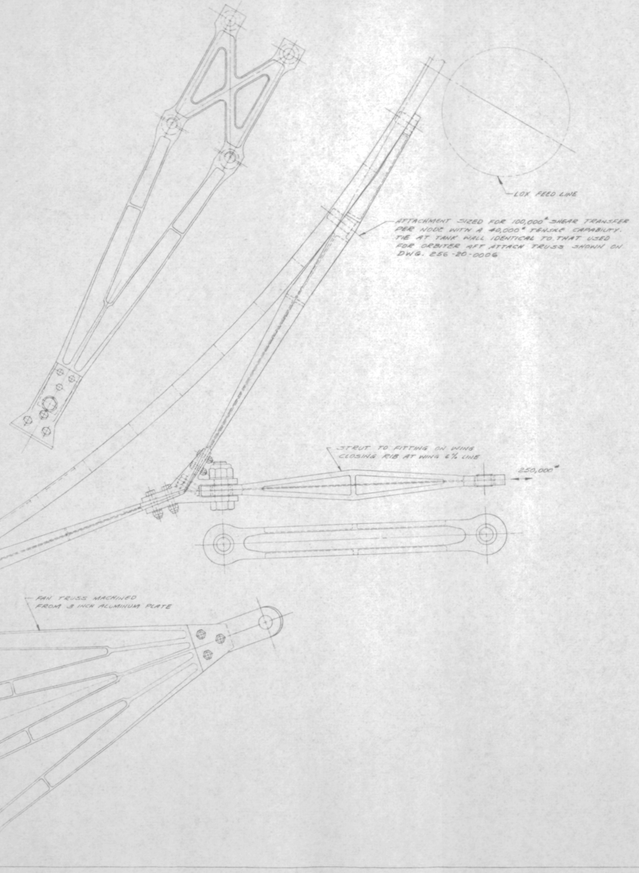
MATERIAL STEEL

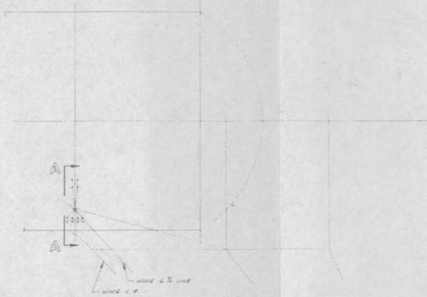
$WT = (.53\ IN^3)(.286\ LB/IN^3) = .15\ LBS$

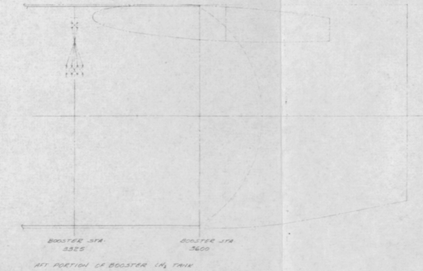


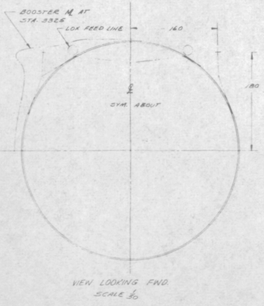
SECTION B - B
SCALE 1"











VIEW LOOKING FWD.
SCALE 1/2"

CONTRACT NO.		MCDONNELL DOUGLAS ASTRONAUTICS CO.	
ORIGINAL DATE OF DRAWING		LAYOUT - WING LEADING EDGE ATTACHMENT	
PREPARED			
CHECKED			
RELEASED			
DESIGN ACTIVITY APPROVAL		SIZE: D	CODE IDENT NO. 18355
CUSTOMER APPROVAL			DRAWING NO. 256-20-0007
			SHEET 1 OF 1